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AN ASSESSMENT OF BUFFER ZONE EFFECTIVENESS IN REDUCING PESTICIDE RUNOFF FROM POTATO FIELDS IN PRINCE EDWARD ISLAND (2001-2002)

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AN ASSESSMENT OF BUFFER ZONE EFFECTIVENESS IN REDUCING PESTICIDE RUNOFF FROM POTATO FIELDS IN PRINCE EDWARD ISLAND (2001-2002)

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ABSTRACT

Intensive use of pesticide chemicals on agricultural lands in Prince Edward Island (PEI) is known to cause impacts on surface water quality and aquatic organisms, particularly during rainfall events. Provincial legislation requiring minimum acceptable buffer zone widths was enacted in April 2000 (Environmental Protection Act, Section 11.1), which requires a minimum 10 metre buffer zone be created between agricultural fields and water courses on lands where the slope is less than 5%. For lands with slopes greater than 5%, the Act requires a 20 metre buffer zone. This was done in an effort to decrease the amounts of particulates, nutrients, pesticides and organic matter entering waterways across PEI. That was considered essential due to the increase in pesticide-induced fish kills which have occurred during the past 10 years. The goal of this study was to measure contaminant concentrations and toxicity of runoff from potato fields prior to and after traversing buffer zones of different widths.

During the growing seasons of 2001 and 2002, Environment Canada undertook a study of the pesticide concentrations and toxicity in runoff at various distances from potato fields which had grassed buffers (0 m, 10 m and in 2002, 30 m) with varying slopes (from 1.7% to 9%). Five fields were monitored in 2001, and measurements were taken after two rainfall events which produced runoff. Six different fields were monitored in 2002, and measurements were taken after seven rainfall events which produced runoff. Aqueous and particulate samples collected were analysed by the Environmental Conservation Branch (ECB) lab in Moncton, New Brunswick, for specific pesticide concentrations (azinphos-methyl, endosulfan, chlorothalonil, phorate, and imidacloprid in 2001, and azinphos-methyl, endosulfan, chlorothalonil, linuron, carbofuran, metobromuron, and imidacloprid in 2002), un-ionized ammonia, and toxicity to *Daphnia magna*.

The most commonly used active ingredients in 2001 and 2002 were: dimethoate and endosulfan (in 2001) and imidacloprid and methamidophos (in 2002) as insecticides; mancozeb and chlorothalonil as fungicides; and metribuzin as a herbicide.

Sample preservation methods differed from 2001 to 2002 for the chemistry samples. In 2001, samples were filtered prior to preservation and in 2001 samples were filtered following preservation which appeared to cause a re-dissolution of pesticides adsorbed to particulates. As such, the chemistry results from these two years are not directly comparable and have been interpreted separately.

In 2001, pesticide concentrations in the aqueous and particulate phases decreased with distance from the field. Mean concentrations of azinphos-methyl and chlorothalonil in the aqueous portion of the sample exceeded the literature-based acute toxicity values for Daphnia magna at 0 m but not at 10 m. No other pesticides exceeded their acute toxicity values for Daphnia at 0 m or 10 m.

In 2002, with the exception of imidacloprid in the aqueous phase, mean pesticide concentrations in the aqueous and particulate phases decreased with distance from the field. Mean imidacloprid concentrations decreased from 0 m to 10 m, and increased from 10 m to 30 m. Due to the solubility of imidacloprid in water and since samples were collected at 30 m at one field only, the chemical composition and/or specific field dynamics may have contributed to this result. None of the mean pesticide concentrations in the aqueous portion of the sample exceeded acute toxicity values for Daphnia magna at 0, 10 or 30 m.

Samples collected for un-ionized ammonia and toxicity to *Daphnia magna* were not preserved and were collected using the same methodology in both years, therefore, these datasets were combined to determine the general effectiveness of the 10 m buffer in 2001 and 2002.

Because it is highly water soluble, un-ionized ammonia was analysed in the aqueous phase only. The mean concentration of un-ionized ammonia for both 2001 and 2002 decreased from 0 m to 10 m and from 10 m to 30 m. Concentrations exceeding the acute toxicity value for Daphnia magna were

identified at 0 m but not at 10 m or 30 m, however, concentrations exceeding the acute toxicity value for salmonids were identified at both the 0 m and 10 m distance but not at 30 m from the field. The results suggest that overall ammonia concentrations in runoff samples may present as high, if not higher risk to fish than do the pesticide residues measured.

The combined 2001 and 2002 *Daphnia magna* results also showed decreasing toxicity with distance from the field. Elevated toxicity (>50% mortality or immobilization) was identified in 2001 in nine of 31 samples at 10 m (29%), and in one of five samples at 30 m (20% of the samples collected at 30 m). Although there was 100% *Daphnia* mortality in a few samples even up to distances of 30 m, mean immobilization rates exceeded 50% only at 0 m and mean mortality below 50% at all distances measured.

Pearson product moment correlations were evaluated by comparing the following parameters: field and buffer slope, rainfall amounts and intensity, pesticide chemistry data, un-ionized ammonia, and *Daphnia* toxicity. These correlations were evaluated for the chemistry data from 2001 and 2002 separately, but were evaluated for both 2001 and 2002 combined for the *Daphnia* toxicity and the un-ionized ammonia results. Due to a limited number of samples in 2001, no statistically significant correlations ($P<0.05$) could be made between pesticide concentrations, un-ionized ammonia concentrations, slope, total rainfall, maximum rainfall, and *Daphnia* toxicity.

In 2002, due to a sufficient number of samples, Pearson product moment correlations could be derived. Statistically significant correlations were identified between chlorothalonil concentrations and *Daphnia* immobility and *Daphnia* mortality ($P=0.0262$ and $P=0.0166$, respectively), and between un-ionized ammonia concentrations and *Daphnia* immobility and *Daphnia* mortality ($P=0.0178$ and $P=0.0298$, respectively). No statistically significant correlations were identified between *Daphnia* effects and other pesticides, slope, total rainfall and/or maximum rainfall.

For the combined dataset from 2001 and 2002 for un-ionized ammonia and *Daphnia* toxicity, a statistically significant correlation was identified between un-ionized ammonia and *Daphnia* mortality ($P=0.0414$).

Based on the results presented in this report, in 2001, the 10 m buffer zone was generally effective in reducing the pesticide concentrations of the runoff. In 2002, the 10 m buffer zone was effective at reducing the analysed pesticide concentrations, however, it was not effective at reducing the un-ionized ammonia to concentrations below acute toxicity values for *Daphnia magna*. The combined results of 2001 and 2002 toxicity testing indicated that there was generally a reduction in toxicity with distance from the edge of fields; however, that reduction was greatest from 0 to 10 m and there was very little difference from 10 to 30 m. In addition, chlorothalonil and un-ionized ammonia were strongly correlated with *Daphnia* toxicity indicating that the presence of elevated concentrations of either of these substances were associated with elevated toxicity, more than with the other parameters analysed.

RÉSUMÉ

L'utilisation intensive de pesticides chimiques sur les terres agricoles de l'Île du Prince-Édouard (Î.P.-É.) influe sur la qualité des eaux de surface et sur les organismes aquatiques, notamment lorsqu'il pleut. Une loi provinciale édictée en avril 2000 (l'*Environmental Protection Act*, article 11.1), exige l'aménagement d'une zone tampon d'au moins 10 mètres entre les champs cultivés et les cours d'eau lorsque la pente du terrain est inférieure à 5 %. La zone tampon minimale requise est de 20 mètres lorsque la pente est supérieure à 5 %. Cette mesure a été adoptée afin de réduire les quantités de particules, d'éléments nutritifs, de pesticides et de matière organique qui aboutissent dans les voies d'eau de la province. Elle était jugée essentielle du fait de l'augmentation de la mortalité des poissons causée par les pesticides au cours des 10 dernières années. La présente étude avait pour objectif de mesurer la concentration des contaminants et la toxicité de l'eau de ruissellement provenant de champs de pommes de terre, avant et après la traversée de zones tampons de diverses largeurs.

Pendant les saisons de croissance 2001 et 2002, Environnement Canada a mesuré les concentrations de pesticides et la toxicité de l'eau de ruissellement à diverses distances de champs de pommes de terre entourés de zones tampons enherbées (0 et 10 m en 2001; 0, 10 et 30 m en 2002) et dont la pente variait de 1,7 à 9 %. En 2001, les mesures ont été réalisées dans cinq champs après deux épisodes de pluie suivis de ruissellement. En 2002, elles ont été prises dans six champs différents après sept épisodes de pluie suivis de ruissellement. Les échantillons d'eau et de particules recueillis ont été analysés au laboratoire de la Direction de la conservation de l'environnement (DCE) à Moncton (Nouveau-Brunswick). On a déterminé les concentrations de pesticides particuliers (azinphos-méthyl, endosulfan, chlorthalonil, phorate et imidaclopride en 2001; azinphos-méthyl, endosulfan, chlorthalonil, linuron, carbofuran, métobromuron et imidaclopride en 2002) et d'ammoniaque non ionisée, et la toxicité pour *Daphnia magna*.

Les matières actives les plus communément utilisées pendant la période d'étude étaient le diméthoate et l'endosulfan (en 2001), et l'imidaclopride et le méthamidophos (en 2002) dans les insecticides, le mancozèbe et le chlorthalonil dans les fongicides, et la métribuzine dans les herbicides.

Les méthodes de préservation des échantillons chimiques ont été modifiées de 2001 à 2002. En 2001, les échantillons ont été filtrés avant la préservation; en 2002, la filtration a précédé la préservation, ce qui semble avoir causé une remise en solution des pesticides adsorbés sur les particules. Ainsi, les résultats des analyses réalisées sur les deux groupes d'échantillons ne sont pas directement comparables et ont été interprétés séparément.

Dans les échantillons de 2001, les concentrations de pesticides dans les phases aqueuse et solide diminuaient en fonction de la largeur de la zone tampon. Les concentrations moyennes d'azinphos-méthyl et de chlorthalonil dans la portion aqueuse des échantillons dépassaient les seuils de toxicité aiguë pour *Daphnia magna* indiqués dans la documentation scientifique à 0 m, mais pas à 10 m. Aucun autre pesticide ne dépassait les seuils de toxicité pour *Daphnia* dans ces échantillons.

Dans les échantillons de 2002, exception faite de l'imidaclopride dans la phase aqueuse, les concentrations moyennes de pesticides dans les phases aqueuse et solide diminuaient en fonction de la distance du champ. Les concentrations moyennes d'imidaclopride diminuaient entre 0 et 10 m, et augmentaient ensuite de 10 à 30 m. Compte tenu de la solubilité de l'imidaclopride dans l'eau et du fait que les échantillons n'ont été recueillis à une distance de 30 m que pour un seul champ, il est possible que la composition chimique ou des facteurs dynamiques propres au champ aient influé sur ce résultat. Aucune des concentrations moyennes de pesticides dans la phase aqueuse des échantillons n'a dépassé le seuil de toxicité aiguë pour *Daphnia magna* à 0, 10 ou 30 m.

Les échantillons recueillis pour la mesure de la teneur en ammoniaque non ionisée et de la toxicité pour *Daphnia magna* n'ont pas été préservés; la méthode de collecte n'a pas varié et les séries de

données ont donc été combinées aux fins de l'évaluation de l'efficacité générale de la zone de tampon de 10 m en 2001 et 2002.

Étant donné la grande solubilité de l'ammoniaque non ionisée dans l'eau, les concentrations de cette substance n'ont été mesurées que dans la phase aqueuse. Les concentrations moyennes mesurées pour 2001 et 2002 diminuaient entre 0 et 10 m et entre 10 et 30 m. Elles dépassaient le seuil de toxicité aiguë pour *Daphnia magna* à 0 m, mais pas 10 m ni à 30 m. Par ailleurs, les concentrations mesurées dépassaient le seuil de toxicité aiguë pour les salmonidés dans les échantillons recueillis à 0 et à 10 m, mais pas à 30 m du champ. Ces résultats donnent à penser que l'ammoniaque présente dans les échantillons d'eau de ruissellement pourrait dans l'ensemble présenter un risque égal, sinon plus grand pour les poissons que les résidus de pesticides.

Les résultats combinés des tests de toxicité réalisés en 2001 et 2002 sur *Daphnia magna* ont également révélé une baisse de la toxicité en fonction de la largeur de la zone tampon. On a mesuré une toxicité élevée (plus de 50 % de mortalité ou d'immobilisation) en 2001 dans neuf des 31 échantillons recueillis à 10 m (29 %) et dans un des cinq échantillons recueillis à 30 m (20 % des échantillons recueillis à cette distance). Quelques échantillons ont donné un taux de mortalité de 100 % même à 30 m, mais les taux moyens d'immobilisation n'ont dépassé 50 % qu'à 0 m, et la mortalité moyenne est restée inférieure à 50 % pour toutes les distances testées.

Les valeurs du coefficient de corrélation produit-moment de Pearson ont été calculées à partir des paramètres suivants : pente des champs et des zones tampons, volume et intensité des pluies, chimie des pesticides, concentrations d'ammoniaque non ionisée et toxicité pour *Daphnia*. Ces corrélations ont été évaluées séparément pour les données chimiques de 2001 et 2002, mais elles ont été calculées à partir des données combinées des deux années pour la toxicité et pour les concentrations d'ammoniaque non ionisée. Étant donné le nombre limité d'échantillons prélevés en 2001, aucune corrélation statistiquement significative ($P \leq 0,05$) n'a pu être établie entre les concentrations de pesticides, les concentrations d'ammoniaque non ionisée, la pente, la quantité totale et maximale de pluie, et la toxicité pour *Daphnia*.

Le nombre d'échantillons prélevés en 2002 a été suffisant pour calculer les coefficients de corrélation produit-moment de Pearson. Des corrélations statistiquement significatives ont été observées entre les concentrations de chlorthalonil d'une part, et l'immobilisation et la mortalité de *Daphnia* d'autre part ($P = 0,0262$ et $P = 0,0166$ respectivement), et entre les concentrations d'ammoniaque non ionisée d'une part, et l'immobilisation et la mortalité de *Daphnia* d'autre part ($P = 0,0178$ et $P = 0,0298$ respectivement). Aucune corrélation statistiquement significative n'a été établie entre les effets sur *Daphnia* et les concentrations des autres pesticides, la pente, la quantité totale et/ou maximale de pluie.

Les données combinées sur la concentration d'ammoniaque non ionisée et la toxicité pour *Daphnia* en 2001 et en 2002 ont révélé l'existence d'une corrélation statistiquement significative entre ces deux paramètres ($P = 0,0414$).

Les résultats présentés dans le présent rapport portent à conclure qu'en 2001, la zone tampon de 10 m a permis de réduire d'une manière généralement efficace les concentrations de pesticides présentes dans l'eau de ruissellement. En 2002, la zone tampon de 10 m a réduit efficacement les concentrations mesurées de pesticides; elle n'a toutefois pas réduit les concentrations d'ammoniaque non ionisée sous le seuil de la toxicité aiguë pour *Daphnia magna*. Les résultats combinés des tests de toxicité pour 2001 et 2002 laissent conclure que la toxicité diminue d'une manière générale à mesure que l'on s'éloigne du bord du champ. Toutefois, cette réduction est maximale entre 0 et 10 m, et la différence observée par la suite, entre 10 et 30 m, est minime. De plus, la corrélation très étroite observée entre les concentrations de chlorthalonil et d'ammoniaque non ionisée et la toxicité pour *Daphnia* porte à conclure que ces deux substances étaient responsables, plus que tous les autres paramètres étudiés, de la toxicité élevée mesurée au cours des analyses.

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1.0 INTRODUCTION

Intensive use of pesticide chemicals on agricultural lands in Prince Edward Island (PEI) is known to cause impacts on surface water quality and aquatic organisms, particularly during rainfall events. Provincial legislation requiring minimum acceptable buffer zone widths was enacted in April 2000 (Environmental Protection Act, Section 11.1), which requires a minimum 10 metre buffer zone be created between agricultural fields and water courses on lands where the slope is less than 5%. For lands with slopes greater than 5%, the Act requires a 20 metre buffer zone. This was done in an effort to decrease the amounts of particulates, nutrients, pesticides and organic matter entering waterways across PEI. That was considered essential due to the increase in pesticide-induced fish kills which have occurred during the past 10 years. The goal of this study was to measure contaminant concentrations and toxicity of runoff from potato fields prior to and after traversing buffer zones of different widths.

These studies were undertaken during the summers of 2001 and 2002. This report presents the results of the two sampling programs.

2.0 METHODS

In 2001, five potato fields ranging from 20 to 40 hectares in size, with a variety of slopes (ranging from two to eight percent) were established as sampling locations. Sampling equipment was placed at the edge of the potato field (0 metres [m]), and downslope of the field at 10 m within the non-crop buffer zone. The vegetation between the two sampling locations consisted of grass which was sometimes mowed.

In 2002, six potato fields (with two locations in one field) ranging from eight to 61 hectares in size and with a variety of slopes (ranging from 1.2 to 9%) were established as sampling locations. As with the previous year, sampling equipment was placed at the edge of the potato field (0 m) and at 10 m, and also at 30 m (one site only) within the buffer zone. The vegetation between the two sampling locations again consisted of grass which was sometimes mowed.

Table 1 presents the physical characteristics of the selected fields, including the slope of the field and of the buffer zone, and the total area of the field (including cultivated area and buffer zone) in hectares. None of the same fields were used in 2001 and 2002 due to crop rotation. Field identification numbers have been used to ensure confidentiality and are used for the remainder of the report.

Table 1: Physical Characteristics of Selected Potato Fields

Field Identification Number	Field Slope (%)	Buffer Slope (%)	Area of Field (Ha)
2001			
Field 1-2001	7.6	Not measured	25
Field 2-2001	7.6	Not measured	40
Field 3-2001	6.5	Not measured	25
Field 4-2001	7.8	Not measured	20
Field 5-2001	4.6	Not measured	20
2002			
Field 1-2002	9	3.5	20.2
Field 2-2002	3	10	10.1
Field 3-2002	1.2	2.4	8.1
Field 4-2002	2.5	1.7	20.2
Field 5-2002	3.5	3 / 12 / 12	20.2
Field 6-2002	1.7	2.3	48.6
Field 7-2002	1.5	5.4	60.7

Collection units consisted of a v-shaped wooden frame wing collector similar to that described by Daniels and Gilliam (1996), which concentrated and directed runoff from four rows of potatoes into a funnel and sample container which was placed below grade (Photo 1 is an example of the type of v-shaped collection system used). The sampling method did not quantify amount of runoff water or the time/duration of sample collection.

Photo 1: Sampling equipment design

The sampler consisted of a 12 L glass carboy inside a polyvinylchloride (PVC) bucket, which was placed below grade. The opening of the carboy was covered with polyethylene film through which a stainless steel funnel was inserted into the neck of the carboy. A stainless steel funneling system directed runoff into the funnel which was level with grade. Polyethylene film was used around the neck of the carboy to limit the number of insects and other organisms entering and becoming trapped in the carboy. A stainless steel sheet was placed over the entire apparatus in order to protect the sampler from rainfall or other airborne debris.

Samples were collected within 12 hours of any substantial rainfall event. A substantial rainfall was considered to be greater than 20 millimetres (mm) over a 24 hour period.

2.1 2001 Field Sampling

There were two substantial rainfall periods in 2001 (August 28 and September 1). Field rainfall measurements were not taken during 2001. In absence of field data, rainfall amounts from provincial and federal meteorological stations were used for assessment of correlations with pesticide concentrations and toxicity of the collected runoff samples.

The samples were collected from each carboy (where sufficient sample was present) in four 1 L amber glass bottles for chemical analysis and two 1 L clear glass wide-mouth bottles for toxicity. The carboy was removed from the plastic bucket and agitated to suspend any particulates in the sample. Wide-mouthed bottles were filled first (used for the toxicity testing), covered with polyethylene film, the lid was placed metal side to the glass and then tightly screwed on. Amber bottles were then filled with the remaining carboy contents. The carboys were replaced with similar containers that had been cleaned with soap and water, rinsed with distilled water and solvent rinsed with acetone followed by hexane. Stainless steel funnels were cleaned with distilled water and paper towels and rinsed with acetone at the site.

The samples were taken to the Bedeque Bay Environmental Management Association (BBEMA) office in Kinkora, PEI, where the chemical analyses samples were pressure filtered through a Millipore 1.2 micron glass-fibre filter prior to submission to the Environment Canada (EC) Environmental Conservation Branch (ECB) laboratory in Moncton, New Brunswick (NB). The samples for toxicity testing were not filtered prior to submission to the lab.

The filtration unit consisted of a nitrogen tank, a stainless steel air-tight lidded 15 L canister, and a three-legged 15.2 cm diameter stainless steel Millipore filtration system that housed the 1.2 micron pore glass fibre filter. The nitrogen tank was attached to the stainless steel canister and the canister was attached to the filtration system using Teflon tubing. Runoff was shaken and poured into the canister, the lid was sealed, 25 pounds per square inch (psi) of pressure was applied from the nitrogen tank and the runoff was pushed from the canister through the Teflon tube, through the filter contained within the filtration system, collected in 500 mL amber bottles, and preserved with 50 mL pesticide grade preservative methylene chloride (dichloromethane). Upon completion of the filtration, the filter was removed and also placed in a 500 mL amber wide mouthed glass bottle to which was added 50 mL of dichloromethane.

Following filtration, the samples were placed in coolers and delivered to the Environment Canada laboratory in Moncton, NB. Upon arrival at the lab, the temperature of the toxicity sample was measured and recorded. Samples were stored overnight at 4°C and analysis commenced the following day. Where sufficient sample was available, a portion of the sample was filtered through a 1.2 micron filter and the sample was tested for toxicity as both filtered and unfiltered assess for interference from the turbidity and solids in the samples (Environment Canada, 2002). All samples were thoroughly homogenized prior to any sub-sampling for water quality measurements or testing.

2.2 2002 Field Sampling

There were seven substantial rainfall events in 2002 (July 18, July 19, August 5, August 6, August 19, September 5 and September 11). Rainfall gauges were installed at five of the seven fields. Based on the rainfall data from 2002, rainfall measurements varied from field to field (i.e. on August 9, 2002, rainfall amounts ranged from 0 mm to 44 mm between fields). In absence of field data, rainfall amounts from provincial and federal meteorological stations were used to assess correlations with pesticide concentrations and toxicity of the collected runoff samples.

The field sampling methodology was similar to that from 2001, however there were several differences. First, samples were collected in two 1 L glass wide-mouthed bottles and three 50 mL amber glass vials. The three amber vials were preserved with methylene chloride, and covered with aluminum foil (no headspace). Second, samples were not filtered in the field but were submitted to the ECB lab containing both particulate and aqueous phases in each sample container. Third, at the lab, all samples were filtered through glass wool to remove large particulate matter such as insects and vegetation prior to toxicity testing. All samples were thoroughly homogenized prior to any sub-sampling for water quality measurements or testing.

2.3 Chemical Analysis 2001 and 2002

The chemical analyses were completed on both the aqueous and particulate fractions of the samples by the Environment Canada lab and were reported for the aqueous and the particulate portions of the runoff separately.

In 2001, a total of 15 aqueous samples were collected at five fields following two rainfall events (sampled on August 29 and September 2) and analysed for pesticides. Six samples were collected at four fields on August 29 (four at 0 m and two at 10 m), and nine were collected at five fields on September 2 (five at 0 m and four at 10 m). Eleven samples (four on August 29 and seven on September 2) were analysed for imidacloprid and base/neutral pesticides including azinphos-methyl, endosulfan, chlorothalonil, and phorate. Due to a lack of sample volumes, four samples (two on August 29 and two on September 2) were analysed only for imidacloprid. Three of these four samples were at 10 m. See Table A.1 in Appendix A for the summary table of analytical results for 2001.

In 2001, runoff samples were filtered at the BBEMA office prior to preservation and analysis in order to remove the suspended particulate matter. Eleven filters were analysed for base/neutral pesticides (azinphos-methyl, endosulfan, chlorothalonil and phorate), four on August 29 (three at 0 m and one at 10 m), and seven on September 2 (five at 0 m and two at 10 m). Fifteen filters were analysed for imidacloprid, six on August 29 (four at 0 m and two at 10 m), and nine on September 2 (five at 0 m and four at 10 m). See Table A.1 in Appendix A for the summary table of analytical results for 2001.

In 2002, a total of 57 samples were collected at seven fields and analysed for pesticides following seven rainfall events (sampled on July 19, July 20, August 6, August 20, September 5 and September 12). Due to a lack of sample volumes, all 57 samples were analysed for base/neutral pesticides, including azinphos methyl, endosulfan, chlorothalonil, linuron, metobromuron and carbofuran, and 47 samples were analysed for the above-mentioned base/neutrals and imidacloprid. Seven of the ten samples that were not analysed for imidacloprid were at 10 m and three were at 0 m. See Table A.2 in Appendix A for the summary table of analytical results for 2002.

Samples were filtered at the ECB lab, and 50 filters were analysed for the same suite of chemicals as the aqueous portion of the runoff. No filters were analysed for the first rainfall event (July 19, seven samples). See Table A.2 in Appendix A for the summary table of analytical results for 2002.

In order to measure these pesticides in water, the following methodology was used. A measured volume of water (approximately 1 L) was extracted using methylene chloride. The extract was isolated, dried with sodium sulphate, solvent exchanged and concentrated to a volume of 2 mL with toluene. The analytes present in the extract were analysed using a gas-chromatograph/mass spectrometer (GC/MS). The individual concentration of each pesticide was obtained by comparing instrument response to a sample with a calibration curve obtained from instrument responses to a set of standards. The standard detection limit for this method was 0.1 µg/L for each analyte.

A similar process was followed for measuring these pesticides on the filter, where the sample was filtered and the filtrate was subjected to a sonication extraction using methylene chloride. The extract was isolated and concentrated to a volume of 2 mL with toluene. The sample was then analysed using GC/MS. The detection limit for this method was 0.02 µg/g for each analyte.

For quality control purposes, each run consisted of method blanks, standards, spike and duplicate samples.

The identified concentrations in the aqueous phase were compared to the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Aquatic

Life (2001), and also to literature-based 48-hour LC_{50} (lethal concentration in which 50% of a test population dies) for *Daphnia magna*.

2.4 Ammonia Analysis 2001 and 2002

Aliquots of the runoff-samples were analysed for pH and total ammonia by ion-specific electrodes by the ECB lab in 2001 and 2002. The ammonia analysis was performed in duplicate and the mean was calculated. The percentage of un-ionized ammonia present at the *Daphnia magna* test temperature (20 ± 2°C) was calculated using the equation presented in Trussel (1972). The standard detection limit for un-ionized ammonia was 0.01 mg/L.

Ammonia was analysed because it is a by-product of the break-down of organic matter, such as fertilizers, and is acutely toxic to aquatic organisms at low concentrations. Thus, although not specifically related to pesticide use, ammonia may result from current farming practices and may have an impact on toxicity.

Un-ionized ammonia concentrations were compared to the CCME (1999) freshwater aquatic life guideline of 0.019 mg/L, and also to the literature-based 48-hour LC_{50}s for *Daphnia magna* of 2.94 mg/L (Gersich and Hopkins, 1986) and 96-hour Brook trout (*Salvelinus fontinalis*) and Rainbow trout (*Oncorhynchus mykiss*) LC_{50}s of 0.1 to 1.44 mg/L (International Joint Commission [IJC], 1986), to determine the potential for adverse aquatic effects associated with exposure to the identified concentrations in the runoff samples.

A total of 17 samples were analysed for un-ionized ammonia in 2001 and 58 samples were analysed for un-ionized ammonia in 2002. See Tables A.3 and A.4 in Appendix A for summary tables of un-ionized ammonia results for 2001 and 2002, respectively.

2.5 *Daphnia magna* Test 2001 and 2002

The *Daphnia magna* test was conducted in 2001 and 2002 by the Environment Canada lab to determine mortality and immobility effects on *Daphnia magna* following 48 hour exposure to the non-preserved runoff samples. Test organisms were <24 hour old *Daphnia magna* collected from the laboratory cultures. Testing was conducted according to Environment Canada, Biological Test Method, Acute Lethality Test Using *Daphnia* spp. EPS 1/RM/11 July 1990 (Environment Canada, 1990). Prior to testing, samples were covered and allowed to equilibrate to 20 ± 2°C, and hardness and dissolved oxygen content were adjusted as required.

In 2001, both filtered and unfiltered samples were analysed for Daphnia toxicity. With the exception of two samples, the presence of suspended particulates did not result in increased toxicity. In those two samples where an increase in toxicity was identified, the concentrations of pesticides absorbed to particulates were qualitatively assessed to determine whether these pesticides may be responsible for the elevated toxicity. Therefore, in 2001, in this report, the toxicity results were compared primarily to the pesticides present in the aqueous phase.

In 2002, all samples were filtered through glass wool only in order to remove large particulates and vegetation prior to toxicity testing using *Daphnia magna*. Only the filtered samples were analysed for Daphnia toxicity. Therefore, in this report, the toxicity results were compared only to pesticides identified in the aqueous phase.

A total of 17 samples were analysed for toxicity to *Daphnia magna* in 2001 and 59 samples were analysed for toxicity to *Daphnia magna* in 2002. The corresponding controls for the toxicity tests were all valid; as no stressed behaviour or mortalities were observed in any of the test beakers in 2001 and

2002. See Tables A.5 and A.6 in Appendix A for summary tables of toxicity results for 2001 and 2002, respectively.

Daphnia were used for toxicity testing because they have a similar sensitivity to pesticides as other aquatic organisms (including salmonid species such as Rainbow trout and Brook trout) and are smaller and less expensive to use than fish assays. However, *Daphnia* are not as sensitive to un-ionized ammonia as salmonids (48-hour LC_{50} of 2.94 mg/L for *Daphnia* and 96-hour LC_{50} between 0.1 and 1.44 mg/L for salmonids), and because of this, in the discussion of un-ionized ammonia in this report, the identified concentrations have been compared to the LC_{50} values for both *Daphnia* and salmonids reported in the literature.

2.6 Statistical Analysis

For the 2001 data, means and standard errors were calculated for each of the pesticides analysed for all of the fields sampled in order to determine general trends in pesticide concentrations between 0 m and 10 m. In addition, Pearson product moment correlation statistics were carried out on the pesticide chemistry data in comparison to the field slope, rainfall amounts and intensity, un-ionized ammonia, and *Daphnia* toxicity. Pearson product moment correlations express the degree of linear relationship between two measured variables. The pair(s) of variables with positive correlation coefficients and *P*-values below 0.05 tend to increase together. For the pairs with negative correlation coefficients and *P*-values below 0.05, one variable tends to decrease while the other increases. For pairs with *P*-values greater than 0.05, there is no significant relationship between the two variables. Due to the limited number of samples, statistically significant correlations were unable to be determined.

For the 2002 data, means and standard errors were again calculated for each of the pesticides analysed for all of the fields sampled to assess the effectiveness of the 10 m buffer in reducing mean pesticide concentrations. In addition, Pearson product moment correlations statistics were carried out on the pesticide data in comparison to field slope, buffer slope, rainfall amounts and intensity, un-ionized ammonia, and *Daphnia* toxicity.

The calculation of the means and correlation statistics for the analysed pesticides in 2001 were conducted separately from the 2002 data due to the different field collection techniques which had had an impact on the analytical results (field filtration prior to sample preservation in 2001 and sample preservation prior to filtration in 2002). The addition of preservatives prior to filtration and analysis resulted in the re-dissolution of pesticides adsorbed to the particulate phase, elevating pesticide concentrations in the aqueous portion of the sample in comparison to the filter in 2002.

In 2001, toxicity testing was conducted using *Daphnia magna* with both filtered and unfiltered samples. In 2002, toxicity testing was conducted using *Daphnia magna* with only filtered samples. In order to determine whether there was a statistically significant difference between *Daphnia* mortality and immobilization in filtered and unfiltered samples from 2001, an analysis of variance (ANOVA) was conducted using SYSTAT Version 8.0.

For the un-ionized ammonia and filtered *Daphnia* toxicity results, the data from 2001 and 2002 were combined together in order to increase the size of the dataset and because none of these samples had been preserved prior to analysis. Mean and standard errors were calculated for un-ionized ammonia and *Daphnia* toxicity (including immobilization and mortality endpoints) to determine the general effectiveness of the 10 m buffer in reducing ammonia and toxicity for both 2001 and 2002. In addition, Pearson product moment correlation statistics were conducted on the dataset comparing un-ionized ammonia to *Daphnia* immobility and mortality for both 2001 and 2002.

3.0 RESULTS AND DISCUSSION

3.1 Pesticides Results - 2001 and 2002

3.1.1 Pesticides Used

Following the potato harvests in 2001 and 2002, the farmers provided Environment Canada with a list of the pesticides used on the fields during those years. Tables 2 and 3 present a summary of the pesticides used on the fields in 2001 and 2002. Where the farmer did not provide the volume used, it was assumed that the pesticide was applied at the standard acceptable rate for potatoes as identified on the product label (PMRA, 2002). The pesticide active ingredients (a.i.) highlighted in bold indicate those compounds that were analysed as part of the chemical analyses.

Table 2: Pesticides Used at Fields Sampled 2001

Trade Name (Type of Application)	Active Ingredient (a.i.) (bolded values indicate pestides that were analysed as part of this study)	Number of Fields Sprayed	# of Applications per season	Average Amount of a.i. Sprayed per Field Per Application (kg/Ha)
INSECTICIDES				
Lagon (foliar)	Dimethoate (480 g/L)	3 of 5	1	0.264 -0.528
Thiodan (foliar)	**α- and β-Endosulfan (400 g/L)**	3 of 5	1	0.6-0.8
Admire (in-furrow)	Imidacloprid (240 g/L)	1 of 5	2	0.204-0.312
Guthion (foliar)	**Azinphos-methyl (240 g/L)**	1 of 5	1	0.42
FUNGICIDES				
Dithane (foliar)	Mancozeb (80%)	5 of 5	2-13	0.88-1.8
Bravo (foliar)	**Chlorothalonil (500 g/L)**	3 of 5	3	0.6 - 1.2
Manzate (foliar)	Mancozeb (75%)	3 of 5	1	1.68
Quadris (foliar)	Azoxystrobin (250 g/L)	3 of 5	1	0.125
Ridomil (foliar)	**Chlorothalonil (500 g/L)** Metalaxyl-M (480 g/L)	3 of 5	1	1.1
HERBICIDES				
Sencor (foliar)	Metribuzin (500 g/L)	4 of 5	1	0.425-1.125
Prism (foliar)	Rimsulfuron (250 g/L)	3 of 5	1	0.015
Venture (foliar)	Fluazifop-P-butyl and S-isomer (125 g/L)	3 of 5	1	0.25
Gramoxone (foliar)	Paraquat (132 g/L) Diquat (66 g/L)	1 of 5	1	0.264-0.528

Table 3: Pesticides Used at Fields Sampled 2002

Trade Name (Type of Application)	Active Ingredient (a.i.) (bolded values indicate pestides that were analysed as part of this study)	Number of Fields Sprayed	# of Applications per season	Average Amount of a.i. Sprayed per Field Per Application (kg/Ha)
INSECTICIDES				
Admire (in-furrow)	**Imidacloprid (240 g/L)**	7 of 7	1	0.0334-0.312
Monitor (foliar)	Methamidophos (480 g/L)	2 of 7	1	0.79-1.08
Ripcord (foliar)	Cypermethrin (407 g/L)	1 of 7	1	0.025-0.0509
Thiodan (foliar)	**α- and β-Endosulfan (400 g/L)**	1 of 7	1	0.6-0.8

Table 3: Pesticides Used at Fields Sampled 2002

Trade Name (Type of Application)	Active Ingredient (a.i.) (bolded values indicate pestides that were analysed as part of this study)	Number of Fields Sprayed	# of Applications per season	Average Amount of a.i. Sprayed per Field Per Application (kg/Ha)
FUNGICIDES				
Ridomil (foliar)	**Chlorothalonil (500 g/L)** Metalaxyl-M (480 g/L)	5 of 7	1	1.056-1.1
Dithane (foliar)	Mancozeb (80%)	3 of 7	8-9	1.79-1.8
Manzate (foliar)	Mancozeb (75%)	3 of 7	1-8	1.68
Bravo (foliar)	**Chlorothalonil (500 g/L)**	4 of 7	5-7	0.6-1.2
Senator (foliar)	Thiophanate-methyl (70%)	2 of 7	1	0.294-0.392
HERBICIDES				
Sencor (foliar)	Metribuzin (500 g/L)	3 of 7	1	0.412
Prism (foliar)	Rimsulfuron (250 g/L)	2 of 7	1	0.015
Lorox (foliar)	**Linuron (0.48 kg/L)**	1 of 7	1	1.56

As indicated in Table 2, in 2001, the most commonly used insecticide a.i.s were dimethoate and endosulfan; the fungicides used were mancozeb and chlorothalonil; and the herbicide used was metribuzin. As indicated in Table 3, in 2002, the most commonly used insecticide a.i.s were imidacloprid and methamidophos; the fungicides used were chlorothalonil and mancozeb; and the herbicide used was metribuzin.

Metribuzin, mancozeb, rimsulfuron, paraquat, diquat, metalaxyl-m, fluazifop-P-butyl and S-isomer, azoxystrobin, dimethoate, methamidophos, cypermethrin and thiophanate-methyl were used in the sampled fields but not analysed by the ECB lab. The reasons for this were because either the farmer did not indicate these pesticides would be used in the upcoming field season, and/or the aquatic toxicity was low compared to other pesticides analysed, and/or the usage was low, and/or there was no standard analytical procedure to test for the presence of the specific pesticide (such as ethylene bisdithiocarbamate, the primary component of mancozeb).

A summary table of the aquatic toxicity (primarily to *Daphnia magna* and Rainbow trout [*Oncorhynchus mykiss*]) and basic chemical properties of all pesticides reported as having been used on the study fields or were identified in the analytical chemistry results is presented in Appendix C.

3.1.2 Aqueous Pesticide Concentrations - 2001

Of the 15 aqueous samples collected during the 2001 field season, the pesticide a.i.s identified at individual fields were azinphos-methyl, endosulfan, chlorothalonil, and imidacloprid. All samples analysed for base/neutral pesticides contained detectable concentrations of one or more pesticide, and none of the samples analysed solely for imidacloprid contained detectable concentrations of that pesticide. No detections were measured for phorate, the only other pesticide analysed in 2001.

With the exception of one sample event each for two pesticides (azinpho-methyl in Field 1 on September 2, and chlorothalonil in Field 1 on August 29), pesticide concentrations decreased from 0 m to 10 m. For the two samples with greater concentrations at 10 m, there was a 25% increase for azinphos-methyl from 0 m to 10 m, and an 82% increase for chlorothalonil from 0 m to 10 m. Neither pesticide was reported by the grower as having been applied to that field during the 2001 field season. The two pesticides where no use pattern was identified may have been present due to one or more of the following: spray drift from other fields during pesticide application; cross contamination by field personnel when collecting samples; and/or the use of equipment by the farmer that had previously been used to spray for these other pesticides. No statistically significant correlations ($P \leq 0.05$) could

be made between the increase in pesticide concentration and rainfall amounts, field slope length, or field or buffer slope gradient.

The mean pesticide concentrations (including standard errors) in the aqueous portion of the runoff at 0 and 10 m were compared and the results are presented in Figure 1, below. Where detectable and non-detectable concentrations were identified for a specific pesticide, the non-detectable results were assumed to be at the detection limit for the purpose of statistical analyses. ND indicates non-detectable concentrations in all samples for that specific parameter. Included in Figure 1 are the literature-based 48-hour LC_{50} for *Daphnia magna* for each of the pesticides.

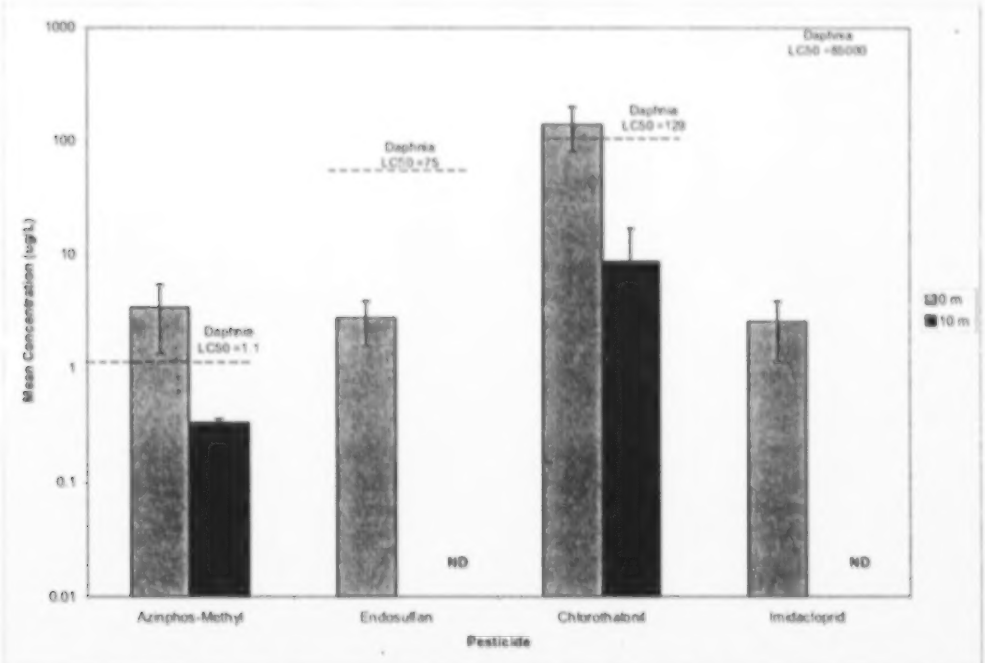


Figure 1: Mean (including standard error) pesticide concentrations in aqueous phase at 0 and 10 m – 2001

As indicated in Figure 1, the mean pesticide concentrations decreased with distance from the field, with no detectable endosulfan or imidacloprid concentrations at 10 m. In addition, mean concentrations of azinphos-methyl and chlorothalonil exceed the literature-based 48-hour LC_{50}s for *Daphnia magna* at 0 m but not at 10 m (discussed further in Section 3.3).

3.1.3 Particulate Pesticide Concentrations - 2001

All eleven filters analysed for base/neutrals contained detectable concentrations of at least one pesticide and two of the fifteen filters analysed for imidacloprid (13%) contained detectable concentrations of imidacloprid.

In those fields with samples at 0 m and 10 m, decreasing chlorothalonil particulate concentrations were identified on the filters from Field 1-2001 and Field 5-2001 (25% and 99%, respectively), and decreasing endosulfan particulate concentrations were identified on the filters from Field 5-2001 (97%). In Field 1-2001, increasing particulate concentrations of endosulfan were identified on August 29, and the same concentration was identified at 0 m and 10 m on September 2.

The mean pesticide particulate concentrations (including standard errors) at 0 and 10 m were compared and the results are presented in the Figure 2, below. Where detectable and non-detectable concentrations were identified for a specific pesticide, the non-detectable results were assumed to be at the detection limit for the purpose of statistical analyses. ND indicates non-detectable concentrations in all samples for that specific parameter. See Table A.1 in Appendix A for the complete analytical results.

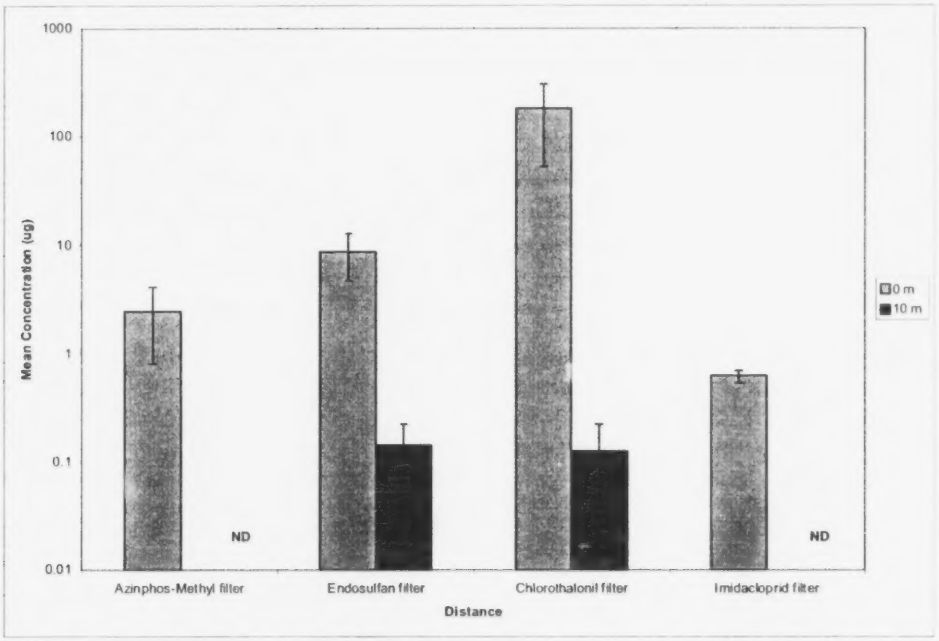


Figure 2: Mean (including standard error) pesticide concentrations in particulate phase at 0 and 10 m - 2001

As indicated in Figure 2, mean pesticide concentrations decreased with distance in the particulate portion of the samples. These results indicate that the buffer was successful in reducing the pesticide concentrations adsorbed to particulates, which may indicate that the grass buffer assisted in reducing the total loading of particulates from the field through the grassed buffer.

3.1.4 Comparison of Aqueous Pesticide Concentrations to Particulate Pesticide Concentrations (2001)

Given that the particulates were collected on a filter based on filtering a 1 L aqueous sample, for the purposes of comparison, the results of the particulate pesticide analysis can be compared with the aqueous samples reported in µg/L. Where less than a 1 L sample was provided to the lab, pesticide concentrations on the filter were adjusted to account for the different volume. Figure 3 presents a comparison of the mean pesticide concentrations (including standard errors) in the aqueous and particulate portions of the runoff based on distance and on chemical. Where detectable and non-detectable concentrations were identified for a specific pesticide, the non-detectable results were assumed to be at the detection limit for the purpose of statistical analyses. ND indicates non-detectable concentrations in all samples for that specific parameter.

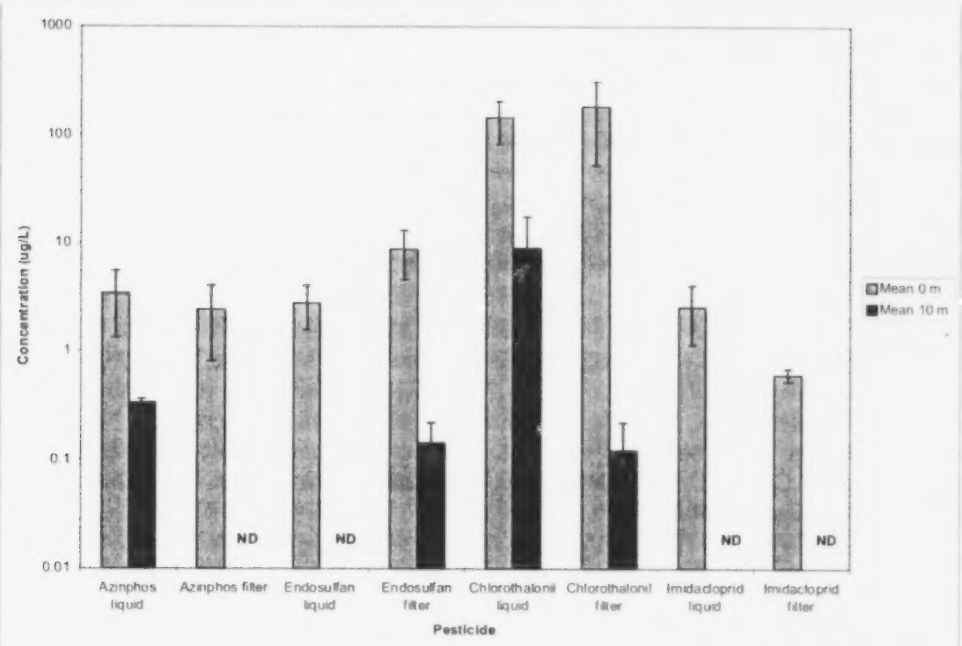


Figure 3: Mean (including standard errors) pesticide concentrations in aqueous and particulate phases by pesticide - 2001

The results of the comparison of aqueous and particulate pesticide concentrations indicate that the more water soluble pesticides are typically present in higher concentrations in the aqueous portion of the sample (i.e. azinphos-methyl and imidacloprid) and the less soluble pesticides are typically present in higher concentrations adsorbed to the particles collected on the filter (i.e. endosulfan and chlorothalonil).

3.1.5 Aqueous Pesticide Concentrations - 2002

Of the 57 samples collected and analysed for pesticides, seventeen (30%) had no detectable concentrations; seven at 0 m (41% of the detectable, 12% of the total samples), nine at 10 m (53% of the detectable, 16% of the total samples) and one at 30 m (6% of the detectable, 2% of the total samples). The non-detectable results were identified on July 19 (one), July 20 (two), August 7 (five), August 20 (two), September 6 (three), and September 12 (four), at Field 3-2002, Field 5-2002, Field 6-2002, and/or Field 7-2002. Table B.1 in Appendix B presents the fields where sample collection occurred, the number of samples collected and the total number of those that were analysed for specific pesticides. See Table A.2 in Appendix A for the summary table of chemistry results.

The pesticide a.i.s identified at one or more fields in more than one sample were chlorothalonil, linuron and imidacloprid. Endosulfan was identified in one field only in two samples at 0 m. Carbofuran was identified in one field and in one sample only at 0 m. No samples contained detectable concentrations of metobromuron or azinphos-methyl, the only other pesticides analysed in 2002.

Two samples from Field 2-2002 and one from Field 5-2002 showed a 100% increase in chlorothalonil concentrations between 0 m and 10 m during different sampling events. One sample from Field 2-2002, three from Field 5-2002, and one from Field 6-2002 showed an increase in imidacloprid concentrations with distance, ranging from 53% to 100% increase between 0 m and 10 m and from 25% to 100% increase between 10 m and 30 m. One sample from Field 3-2003 showed a 100% increase in linuron concentrations between 0 m and 10 m, however, this result was considered questionable because of a lab inconsistency (Bernier, personal communication, 2003).

Both chlorothalonil and imidacloprid had been reported as being used on the fields where the concentrations increased from 0 m to 10 m. No statistically significant correlations ($P \leq 0.05$) could be made between the increase in pesticide concentration and rainfall amounts, field slope length, or field or buffer slope gradient.

With the exception of these nine situations, in 22 cases where samples were collected at 0 m and 10m, or at 10 m and 30 m, pesticide concentrations (endosulfan, chlorothalonil, imidacloprid and linuron) decreased from 0 m to 10 m from 54% to 100%, and from 10 m to 30 m from 7% to 100%.

The mean pesticide concentrations (including standard errors) in the aqueous portion of the runoff at 0, 10 and 30 m were compared and the results are presented in Figure 4, below. Where detectable and non-detectable concentrations were identified for a specific pesticide, the non-detectable results were assumed to be at the detection limit for the purpose of statistical analyses. ND indicates non-detectable concentrations in all samples for that specific parameter. Included in Figure 4 are the literature-based 48-hour LC_{50} for *Daphnia magna* for each of the pesticides. See Table A.2 in Appendix A for the complete analytical results.

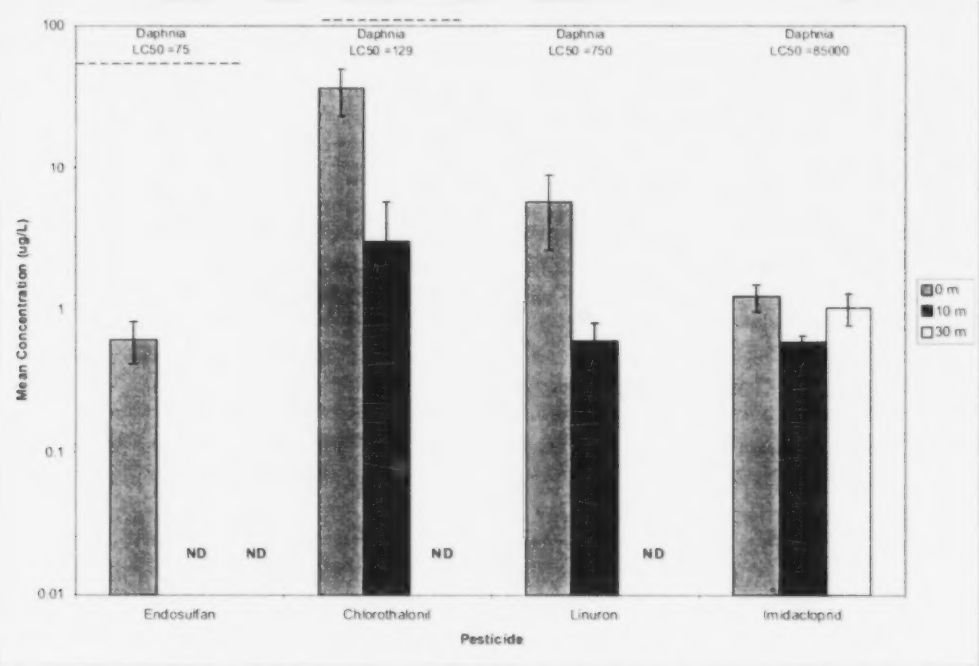


Figure 4: Mean (including standard error) pesticide concentrations in aqueous phase at 0, 10 and 30 m – 2002

As indicated in Figure 4, with the exception of imidacloprid, pesticide concentrations decreased with distance in the aqueous portion of the samples. In addition, none of the identified pesticide concentrations exceeded the literature-based 48-hour LC_{50} for *Daphnia magna* (discussed further in Section 3.3). Imidacloprid is the most water soluble of the pesticides detected, and therefore, in a runoff situation, may migrate farther in the aqueous phase of the runoff as opposed to other pesticides which may adsorb to organic matter and be better contained within the buffer. Given that the 30 m samples were only collected in one field, specific field and/or buffer dynamics may have resulted in the channeling of aqueous phase of the runoff that may have resulted in elevated imidacloprid concentrations at 30 m.

3.1.6 Particulate Pesticide Concentrations - 2002

In 2002, runoff samples were preserved in the field using methylene chloride/dichloromethane and filtered in the ECB lab to remove large particles. As a result of the preservation prior to filtration, adsorbed pesticides were re-dissolved into the aqueous portion of the sample, resulting in very low pesticide concentrations identified in the particulate portion.

Fifty filters were analysed for base/neutral pesticides (azinphos-methyl, endosulfan, chlorothalonil, carbofuran, linuron, and metobromuron) (24 at 0 m, 22 at 10 m and 4 at 30 m), and 41 were analysed for imidacloprid (21 at 0 m, 16 at 10 m, and 4 at 30 m). Where detectable and non-detectable concentrations were identified for a specific pesticide, the non-detectable results were assumed to be at the detection limit for the purpose of statistical analyses. ND indicates non-detectable concentrations in all samples for that specific parameter. See Table A.2 in Appendix A for the complete analytical results.

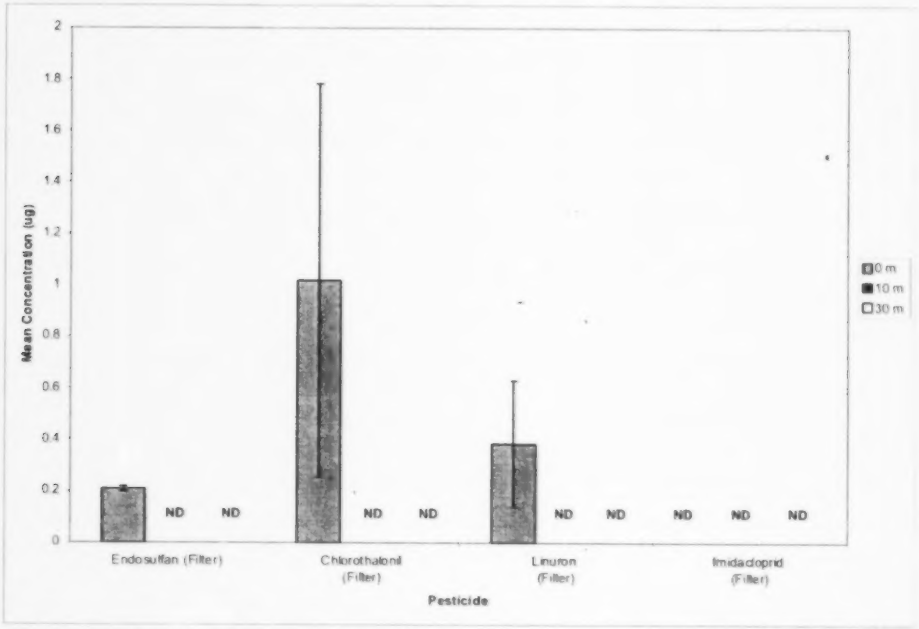


Figure 5: Mean (including standard error) pesticide concentrations in particulate phase at 0, 10 and 30 m – 2002

As indicated in Figure 5, the mean pesticide concentrations decreased with distance from the field in the filter/particulate portion of the runoff samples. The results indicate that the 10 m buffer was sufficient to reduce the concentrations of the analysed pesticides adsorbed to particulates to non-detectable concentrations. However, due to the preservation prior to analysis, these results may not be representative of actual pesticide concentrations adsorbed to particulates at 10 m or 30 m.

3.1.7 Comparison of Aqueous Pesticide Concentrations to Particulate Pesticide Concentrations (2002)

As with the 2001 data, given that the particulates were collected on a filter based on filtering a 1 L liquid sample, for the purposes of comparison, the results of the particulate pesticide analysis can be compared with the aqueous samples reported in µg/L. Figure 6 presents a comparison of the mean pesticide concentrations in the aqueous and particulate portions of the runoff based on distance and based on chemical. Where detectable and non-detectable concentrations were identified for a specific pesticide, the non-detectable results were assumed to be at the detection limit for the purpose of

statistical analyses. ND indicates non-detectable concentrations in all samples for that specific parameter.

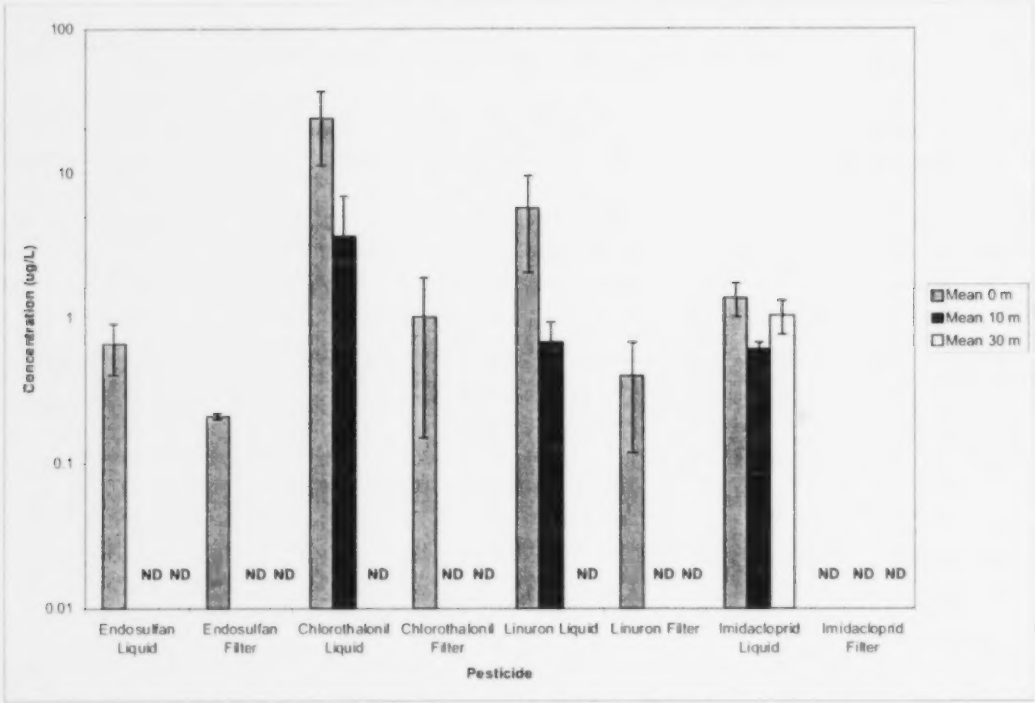


Figure 6: Mean (including standard errors) pesticide concentrations in aqueous and particulate phases by pesticide - 2002

As presented in Figure 6, with the exception of imidacloprid in the liquid samples at 30 m, mean pesticide concentrations were higher at 0 m than at 10 or 30 m in both the aqueous and particulate portions of the sample. In addition, mean pesticide concentrations in the aqueous portion of the sample were higher in comparison to the particulate portion for all of the pesticides analysed. The comparison of aqueous and particulate concentrations indicates that in general, the 10 m buffer reduced pesticide concentrations in the aqueous and particulate phases from 0 to 10 m and from 10 m to 30 m.

3.2 Un-Ionized Ammonia Results – 2001 and 2002

Since none of the samples in 2001 or 2002 were preserved prior to analysis for un-ionized ammonia, they are comparable and can be combined to provide a larger data-set for determining the effectiveness of the 10 m grassed buffer. Figure 7 presents the mean concentrations at 0 m and 10 m, for both 2001 and 2002 samples combined, and includes the 30 m samples collected in 2002. Where detectable and non-detectable concentrations were identified for a specific pesticide, the non-detectable results were assumed to be at the detection limit for the purpose of statistical analyses.

Included in Figure 7 is also the CCME (1999) criteria, and the literature-based 96-hour LC_{50}s for *Daphnia magna* and salmonids. Salmonids, including Brook trout [*Salvelinus fontinalis*] and Rainbow trout [*Oncorhynchus mykiss*]) are more sensitive to un-ionized ammonia than are *Daphnia* (acute lethality for these salmonid fish range from 0.1 to 1.44 mg/L un-ionized ammonia) (IJC, 1986).

ND indicates a non-detectable sample. See Tables A.3 and A.4 in Appendix A for the ammonia results for 2001 and 2002, respectively.

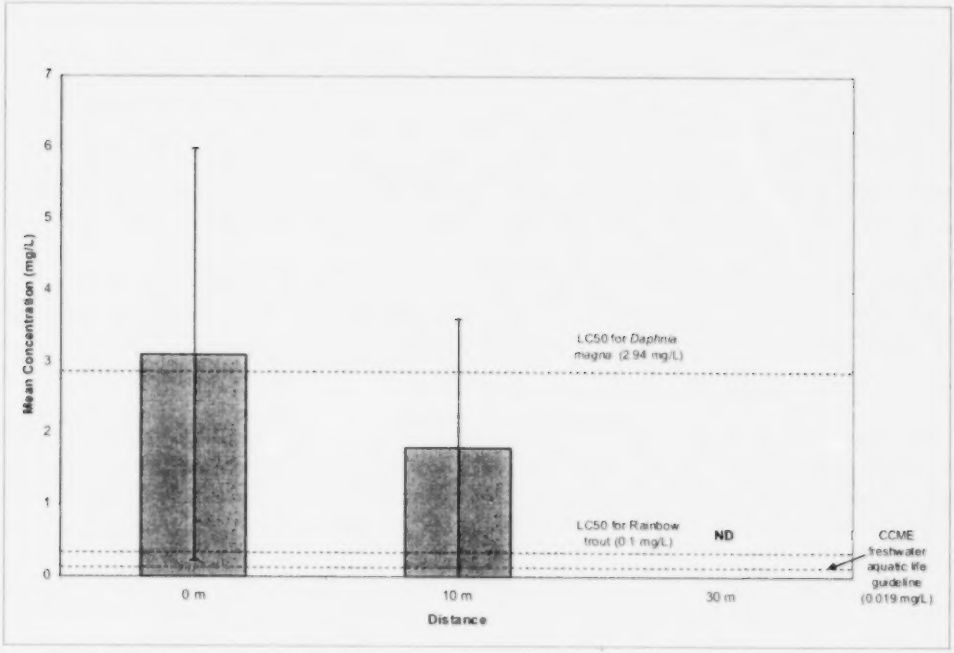


Figure 7: Mean (including standard error) un-ionized ammonia concentrations in aqueous phase – 2001-2002

As presented in Figure 7, the mean concentrations of un-ionized ammonia decreased over distance, with non-detectable concentrations at 30 m. At 0 m and 10 m, however, un-ionized ammonia concentrations exceeded the literature-based 96-hour LC_{50} value for salmonids. Thus, in general, in 2001 and 2002, the grassed buffer reduced the mean un-ionized ammonia concentrations from 0 m to 10 m, however, the mean concentration was still higher than applicable acute toxicity value for salmonids at 10 m.

Thus, in total, for both 2001 and 2002, of the 41 samples analysed for un-ionized ammonia at 0 m, 16 contained detectable concentrations (39%), 12 contained concentrations exceeding 0.019 mg/L (29%) (CCME, 1999), eight contained concentrations exceeding 0.1 mg/L (20%) (IJC, 1986), and four contained concentrations exceeding 2.94 mg/L (10%) (Gersich and Hopkins, 1986). Of the 29 samples analysed at 10 m, nine contained detectable concentrations (31%), six contained concentrations exceeding 0.019 mg/L (21%), four contained concentrations exceeding 0.1 mg/L (14%), and 2 contained concentrations exceeding 2.94 mg/L (7%). Of the 5 samples analysed at 30 m, two contained concentrations (40%) at the detection limit (0.01 mg/L).

The presence of un-ionized ammonia was likely due to an application of fertilizers late in the growing season (late August and early September) as some of the growers indicated they had applied urea at that time. Not all growers indicated that they had used urea, however, since Environment Canada had only requested pesticide spray schedules not and fertilizer application schedules. In addition, the un-ionized ammonia (or a percentage thereof) may also have been the result of the decomposition of insects which entered the sample collectors and were not removed immediately following the runoff event.

The results from 2001 and 2002 indicate that un-ionized ammonia was present in concentrations in the runoff that may be highly toxic to fish, more so than the analysed pesticide concentrations.

3.3 *Daphnia magna* Results - 2001 and 2002

3.3.1 Comparison of Filtered and Un-filtered Toxicity Results - 2001

In 2001, of the seventeen samples tested for toxicity to *Daphnia magna*, eight (47%) were considered 'toxic' to *Daphnia* (>50% immobility or mortality identified in the test population), seven at 0 m and one at 10 m. See Table A.5 in Appendix A for the analytical summary table of the *Daphnia* toxicity results for 2001.

In two of the three samples with elevated toxicity, there was some improvement when the samples were filtered using a 1.2 µm glass-fibre filter (from 100% mortality to 20% mortality [100% immobilized in both cases]; and from 80% mortality to 40% mortality) (Environment Canada, 2002), indicating a small amount of toxicity may have been due to the presence of particulate-sorbed pesticide residues.

In one field, there was 0% mortality in the filtered sample and 60% mortality in the unfiltered sample, indicating that some parameter adsorbed to the particulate matter may have been responsible for the elevated toxicity.

Figure 8 presents the mean (including standard error) *Daphnia* toxicity at 0 and 10 m for both filtered and unfiltered samples for 2001.

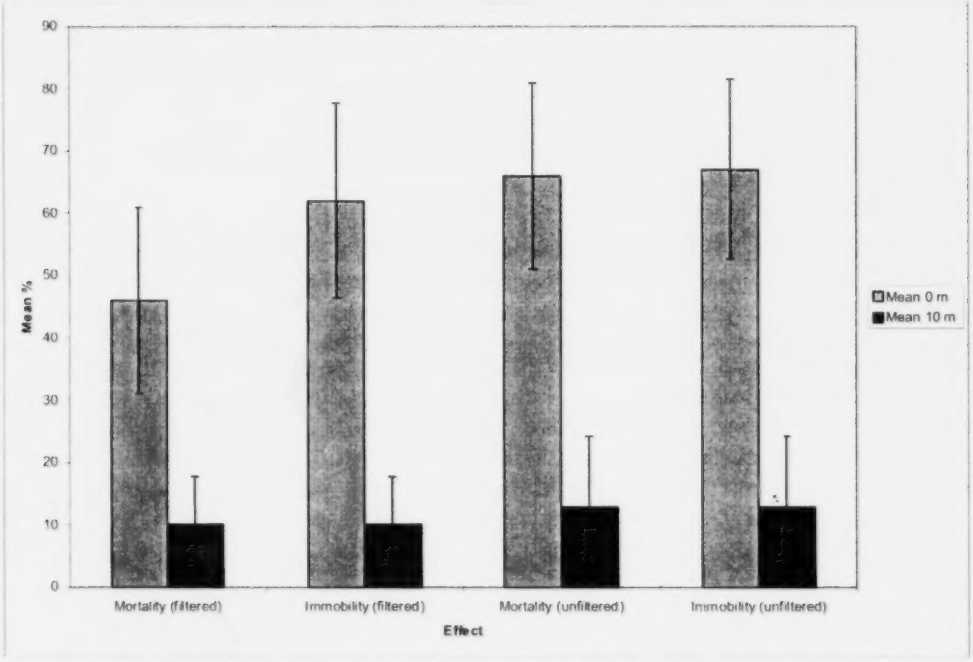


Figure 8: Comparison of mean (including standard error) mortality and immobilization rates for *Daphnia magna* in filtered (using 1.2 µm glass fibre filters) and unfiltered samples – 2001

As indicated in Figure 8, the mean mortality and immobilization rates in the filtered samples were lower than in the un-filtered. However, in order to determine if there were statistically significant differences between filtered and unfiltered results in 2001, the mean (including standard error), was compared using an analysis of variance (ANOVA). The results are presented in Table 4.

Table 4: Comparison of Mean Mortality and Immobilization Rates for Filtered and Unfiltered Samples – 2001

Effect	Mean	Standard Error	*P*-Value
Mortality (filtered)	34	11.032	0.536
Mortality (unfiltered)	44.118	11.665	
Immobility (filtered)	44.667	12.378	0.998
Immobility (unfiltered)	44.706	11.54	

As presented in Table 4, the means for each of the endpoints would indicate similar results irrespective of whether the sample was filtered or not. The *P*-values from the ANOVA results indicate that there are no statistically significant differences between the mortality rates in the filtered and unfiltered samples and between the immobilization rates in the filtered and unfiltered samples.

3.3.2 Comparison of *Daphnia magna* Results – 2001 and 2002

In total, for both 2001 and 2002, >50% immobility was identified in 21 of the 41 samples collected at 0 m (51%), >50% mortality was identified in 17 of the 41 samples collected at 0 m (41%), >50% immobility and mortality was identified in eight of the 28 samples collected at 10 m (29%), and >50% immobility and mortality was identified in one of the five samples collected at 30 m (20%).

Table B.2 in Appendix B presents the fields where collection occurred, the number of samples collected and the total number of those that were toxic to *Daphnia* (≥ than 50% mortality or ≥50% immobilization).

Since none of the samples in 2001 or 2002 were preserved prior to toxicity testing, they are comparable and can be combined to provide a larger data-set for determining the effectiveness of the 10 m grassed buffer. Figure 9 presents the mean *Daphnia magna* mortality percentages at 0 m, 10 m, and 30 m, for both 2001 and 2002 samples. Since only filtered samples were assessed for toxicity in 2002, Figure 9 only presents a comparison of the filtered toxicity data for 2001 and 2002. See Tables A.5 and A.6 in Appendix A for the *Daphnia* toxicity results for 2001 and 2002, respectively.

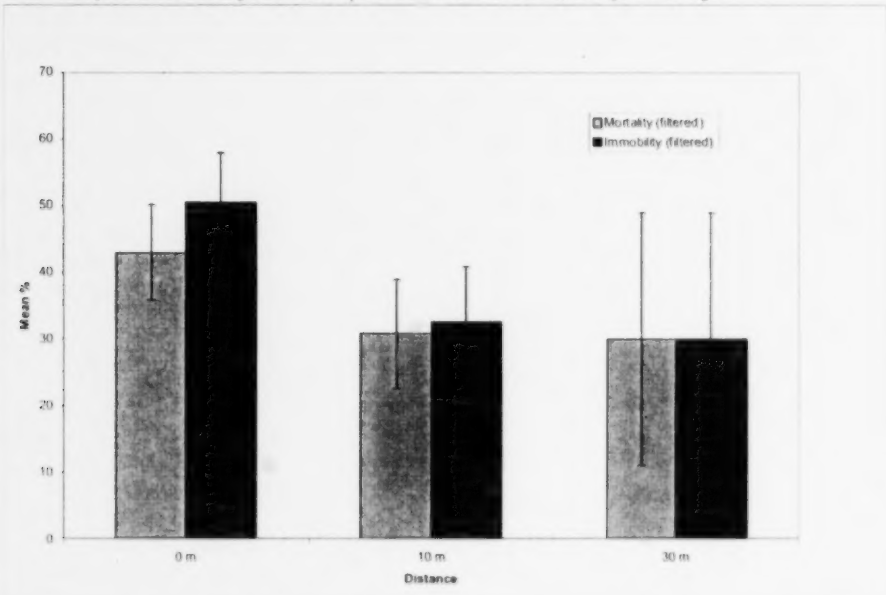


Figure 9: Mean (including standard errors) mortality and immobilization rates for *Daphnia magna* – 2001-2002

As indicated in Figure 9, mean *Daphnia* mortality and immobility decreased between 0 m, 10 m and 30 m. In addition, at 0 and 10 m, the mean immobility percentage was greater than the mean mortality percentage, indicating that exposure to the runoff resulted in greater numbers of *Daphnia* becoming immobilized but not necessarily resulting in death.

3.4 Pesticide and Un-Ionized Ammonia Concentrations Compared to *Daphnia magna* Toxicity 2001-2002

Table 5 presents the number of aqueous samples at 0 and 10 m exceeding the published *Daphnia magna* 48-hour LC_{50} for the specific pesticides, the published *Daphnia* 48-hour LC_{50} and the published 96-hour LC_{50}s for salmonids for the un-ionized ammonia, and also the number of samples exceeding 50% mortality or 50% immobility based on the *Daphnia* toxicity testing conducted by the ECB lab on the runoff samples collected in 2001.

Table 5: Percentage of Total Samples Exceeding Acute Toxicity Values – 2001

Parameter	Total Number of Samples Analysed		Number of Samples Exceeding Acute Toxicity Values /Elevated Toxicity (>50% *Daphnia* mortality/immobility)		Percentage of Total Samples Exceeding Acute Toxicity Values/Elevated Toxicity (%)	
	0 m	10 m	0 m	10 m	0 m	10 m
Azinphos-methyl	9	6	2 (LC_{50})	0	22	0
Endosulfan	9	6	0	0	44	0
Chlorothalonil	9	6	4 (LC_{50})	0	44	0
Imidacloprid	9	6	0	0	0	0
Phorate	9	6	0	0	0	0
Un-ionized Ammonia	9	8	1 (*Daphnia* LC_{50}) 3 (Salmonid LC_{50})	0 (*Daphnia* LC_{50}) 2 (Salmonid LC_{50})	11 (*Daphnia* LC_{50}) 33 (Salmonid LC_{50})	0 (*Daphnia* LC_{50}) 25 (Salmonid LC_{50})
Daphnia toxicity	9	8	7	1	78	13

As indicated in Table 5, all pesticide and un-ionized ammonia concentrations at 10 m were below the applicable 48-hour LC_{50} for *Daphnia magna*, indicating that the pesticides analysed were not at a concentration that should cause elevated toxicity to *Daphnia magna*. However, the un-ionized ammonia concentrations exceeded the acute toxicity value for salmonids in two of the eight samples collected at 10 m. The toxicity test results using *Daphnia magna* indicated lower toxicity to *Daphnia* at 10 m than at 0 m, with only one sample considered toxic (40% mortality in the filtered sample and 80% mortality in the unfiltered sample). The results indicate that the 10 m grassed buffer was successful at reducing pesticide concentrations to below literature-based acute toxicity values for *Daphnia magna*.

Table 6 presents the number of aqueous samples at 0 m, 10 m and 30 m exceeding the published *Daphnia magna* 48-hour LC_{50} for the specific pesticides, the published *Daphnia* 48-hour LC_{50} and the published 96-hour LC_{50}s for salmonids for the un-ionized ammonia, and also the number of samples exceeding 50% mortality or 50% immobility based on the *Daphnia* toxicity testing conducted by the ECB lab on the runoff samples collected in 2002.

Table 6: Percentage of Total Samples Exceeding Acute Toxicity Values – 2002

Parameter	Total Number of Samples Analysed			Number of Samples Exceeding Acute Toxicity Values/Elevated Toxicity (>50% mortality/immobility)			Percentage of total Samples Exceeding Acute Toxicity Values/Elevated Toxicity (%)		
	0 m	10 m	30 m	0 m	10 m	30 m	0 m	10 m	30 m
Endosulfan	28	24	5	0	0	0	0	0	0
Chlorothalonil	28	24	5	3 (LC_{50})	0	0	11	0	0
Imidacloprid	25	17	5	0	0	0	0	0	0
Linuron	28	24	5	0	0	0	0	0	0
Un-ionized Ammonia	31	23	5	3 (*Daphnia* and salmonid LC_{50}s)	2 (*Daphnia* and salmonid LC_{50}s)	0 (*Daphnia* and salmonid LC_{50}s)	10 (*Daphnia* and salmonid LC_{50}s)	9 (*Daphnia* and salmonid LC_{50}s)	0 (*Daphnia* and salmonid LC_{50}s)
Daphnia toxicity	31	23	5	16	8	1	52	35	20

As indicated in Table 6, all pesticide concentrations at 10 m and 30 m were below the applicable 48-hour LC_{50} for *Daphnia magna*, indicating that the pesticides analysed were not at a concentration that should cause toxicity to *Daphnia magna*. Un-ionized ammonia was elevated in two samples at 10 m but not at 30 m (exceeding both the 48-hour LC_{50} for *Daphnia magna* and the 96-hour LC_{50} for salmonids), and toxicity to *Daphnia* were identified in eight samples at 10 m and one sample at 30 m. The results indicate that the 10 m grassed buffer was successful at minimizing the analysed pesticide concentrations, but not successful at decreasing un-ionized ammonia concentrations to below toxic levels at 10 m or eliminating *Daphnia* toxicity at 10 m and 30 m.

In order to determine the rationale for any identified elevated toxicity in 2001 and 2002 at 0 m, 10 m and 30 m, pesticide and un-ionized ammonia concentrations were compared for those samples with elevated *Daphnia* toxicity (8 samples in 2001, and 24 in 2002). Where pesticide or un-ionized ammonia concentrations exceeded the literature-based 48-hour LC_{50} for *Daphnia magna*, it was considered as a potential cause of the elevated toxicity in the sample.

The results of the comparison for 2001 and 2002 are presented in Tables D.1 and D.2 in Appendix D, and are summarized below in Figures 10 and 11.

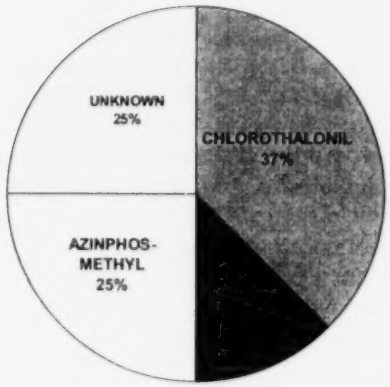


Figure 10: Potential causes of elevated *Daphnia* toxicity - 2001

As presented in Figure 10 and Table D.1 in Appendix D, for 2001, elevated pesticide and/or un-ionized ammonia concentrations corresponded well with the elevated *Daphnia* toxicity, with chlorothalonil, azinphos-methyl and/or un-ionized ammonia elevated in six of the eight samples (75%). Two samples

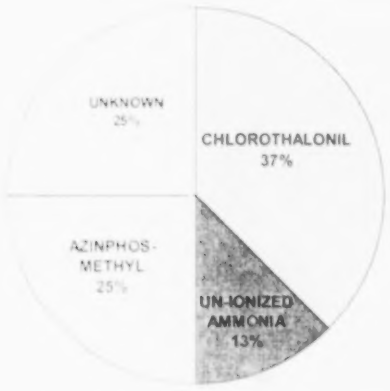
Table 6: Percentage of Total Samples Exceeding Acute Toxicity Values – 2002

Parameter	Total Number of Samples Analysed			Number of Samples Exceeding Acute Toxicity Values/Elevated Toxicity (>50% mortality/immobility)			Percentage of total Samples Exceeding Acute Toxicity Values/Elevated Toxicity (%)		
	0 m	10 m	30 m	0 m	10 m	30 m	0 m	10 m	30 m
Endosulfan	28	24	5	0	0	0	0	0	0
Chlorothalonil	28	24	5	3 (LC_{50})	0	0	11	0	0
Imidacloprid	25	17	5	0	0	0	0	0	0
Linuron	28	24	5	0	0	0	0	0	0
Un-ionized Ammonia	31	23	5	3 (*Daphnia* and salmonid LC_{50}s)	2 (*Daphnia* and salmonid LC_{50}s)	0 (*Daphnia* and salmonid LC_{50}s)	10 (*Daphnia* and salmonid LC_{50}s)	9 (*Daphnia* and salmonid LC_{50}s)	0 (*Daphnia* and salmonid LC_{50}s)
Daphnia toxicity	31	23	5	16	8	1	52	35	20

As indicated in Table 6, all pesticide concentrations at 10 m and 30 m were below the applicable 48-hour LC_{50} for *Daphnia magna*, indicating that the pesticides analysed were not at a concentration that should cause toxicity to *Daphnia magna*. Un-ionized ammonia was elevated in two samples at 10 m but not at 30 m (exceeding both the 48-hour LC_{50} for *Daphnia magna* and the 96-hour LC_{50} for salmonids), and toxicity to *Daphnia* were identified in eight samples at 10 m and one sample at 30 m. The results indicate that the 10 m grassed buffer was successful at minimizing the analysed pesticide concentrations, but not successful at decreasing un-ionized ammonia concentrations to below toxic levels at 10 m or eliminating *Daphnia* toxicity at 10 m and 30 m.

In order to determine the rationale for any identified elevated toxicity in 2001 and 2002 at 0 m, 10 m and 30 m, pesticide and un-ionized ammonia concentrations were compared for those samples with elevated *Daphnia* toxicity (8 samples in 2001, and 24 in 2002). Where pesticide or un-ionized ammonia concentrations exceeded the literature-based 48-hour LC_{50} for *Daphnia magna*, it was considered as a potential cause of the elevated toxicity in the sample.

The results of the comparison for 2001 and 2002 are presented in Tables D.1 and D.2 in Appendix D, and are summarized below in Figures 10 and 11.



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had elevated toxicity only in the unfiltered samples (0% in filtered sample to 60% in unfiltered and 40% in filtered sample to 80% in unfiltered sample), indicating that some parameter associated with the suspended particulates may have been responsible for the elevated toxicity. Endosulfan was the only pesticide detected on one filter (at a concentration of 0.07 µg) for one sample, and the other sample was not analysed for pesticides due to low sample volumes. Therefore, the agent responsible for the elevated toxicity in the two samples is not known but is expected to be associated with the suspended particulate matter.

Figure 11: Potential causes of elevated *Daphnia* toxicity - 2002

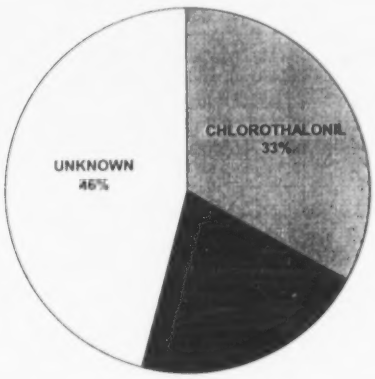
As presented in Figure 11 and Table D.2 in Appendix D, for 2002, the *Daphnia* toxicity results did not correspond as well with the pesticide and/or un-ionized ammonia results as in 2001. For 13 of the 24 samples (54%), chlorothalonil and/or un-ionized ammonia were elevated with and corresponded with the elevated *Daphnia* toxicity.

For the 46% in the 'unknown' category presented in Figure 11, seven of the 24 samples (29%) with elevated toxicity to *Daphnia* contained no elevated pesticide or ammonia concentrations, and all general water quality parameters tested (temperature, dissolved oxygen, pH, conductivity, and hardness) were within acceptable limits. In addition, no other pesticides were reported as having been used on the fields where these samples were collected. Therefore, for these seven samples, the cause of the elevated toxicity is not known.

For the other four samples in the 'unknown' category, use pattern information from the individual growers was consulted to determine if pesticides used but not analysed may have been responsible for the elevated *Daphnia* toxicity. One grower indicated that they had sprayed methamidophos (*Daphnia magna* 48-hour LC_{50} of 0.27 mg/L), and since this pesticide had not been analysed, it may have been present in one of the four samples in concentrations sufficient to cause elevated toxicity, however, this is not known. In addition, the ECB lab conducted a qualitative GC/MS of ethylenethiourea [a break-down product of mancozeb], metribuzin and metalaxyl, and identified peaks in three of the samples with elevated toxicity, indicating the presence of one or more of these other pesticides without quantifying the amounts. The presence of these pesticides in the three of these four samples, alone or in combination with other pesticides, may have been responsible for the elevated *Daphnia* toxicity identified, however, again, this is not known.

No samples were assessed specifically for parameters typically associated with agricultural practices, including specific additives to pesticides (i.e. zinc, manganese, and/or ethylene bis-dithiocarbamate in mancozeb), fertilizers (i.e. potassium, phosphorus, and/or sulfide from decaying organic matter), or break-down products of these substances (i.e. nitrates and nitrites which are part of the nitrogen cycle). These factors, alone or in combination, or also potentially in conjunction with pesticides not analysed,

had elevated toxicity only in the unfiltered samples (0% in filtered sample to 60% in unfiltered and 40% in filtered sample to 80% in unfiltered sample), indicating that some parameter associated with the suspended particulates may have been responsible for the elevated toxicity. Endosulfan was the only pesticide detected on one filter (at a concentration of 0.07 µg) for one sample, and the other sample was not analysed for pesticides due to low sample volumes. Therefore, the agent responsible for the elevated toxicity in the two samples is not known but is expected to be associated with the suspended particulate matter.



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For the 46% in the 'unknown' category presented in Figure 11, seven of the 24 samples (29%) with elevated toxicity to *Daphnia* contained no elevated pesticide or ammonia concentrations, and all general water quality parameters tested (temperature, dissolved oxygen, pH, conductivity, and hardness) were within acceptable limits. In addition, no other pesticides were reported as having been used on the fields where these samples were collected. Therefore, for these seven samples, the cause of the elevated toxicity is not known.

For the other four samples in the 'unknown' category, use pattern information from the individual growers was consulted to determine if pesticides used but not analysed may have been responsible for the elevated *Daphnia* toxicity. One grower indicated that they had sprayed methamidophos (*Daphnia magna* 48-hour LC_{50} of 0.27 mg/L), and since this pesticide had not been analysed, it may have been present in one of the four samples in concentrations sufficient to cause elevated toxicity, however, this is not known. In addition, the ECB lab conducted a qualitative GC/MS of ethylenethiourea [a break-down product of mancozeb], metribuzin and metalaxyl, and identified peaks in three of the samples with elevated toxicity, indicating the presence of one or more of these other pesticides without quantifying the amounts. The presence of these pesticides in the three of these four samples, alone or in combination with other pesticides, may have been responsible for the elevated *Daphnia* toxicity identified, however, again, this is not known.

No samples were assessed specifically for parameters typically associated with agricultural practices, including specific additives to pesticides (i.e. zinc, manganese, and/or ethylene bis-dithiocarbamate in mancozeb), fertilizers (i.e. potassium, phosphorus, and/or sulfide from decaying organic matter), or break-down products of these substances (i.e. nitrates and nitrites which are part of the nitrogen cycle). These factors, alone or in combination, or also potentially in conjunction with pesticides not analysed,

may have been responsible for the elevated *Daphnia* toxicity identified in the eleven samples for which no rationale for the elevated toxicity could be identified.

In 2001, due to the limited number of samples collected no statistically-significant correlations ($P \geq 0.05$) could be made between pesticide concentrations, slope, total rainfall, maximum rainfall, and *Daphnia* toxicity.

In 2002, due to a sufficient number of samples, Pearson product moment correlations were derived (Environment Canada, 2003). Statistically significant correlations were identified between chlorothalonil concentrations and *Daphnia* immobility and *Daphnia* mortality (P=0.0262 and P=0.0166, respectively), and between un-ionized ammonia concentrations and *Daphnia* immobility and *Daphnia* mortality (P=0.0178 and P=0.0298, respectively) (Environment Canada, 2003). No statistically significant correlations were identified between other chemistry data and buffer zone distance, or between buffer zone distance and *Daphnia* toxicity.

Because of the same sampling methods and analytical procedures, correlations could also be derived for the combined dataset from 2001 and 2002 for un-ionized ammonia and *Daphnia* toxicity. A statistically significant correlation was identified between the 2001 and 2002 un-ionized ammonia concentrations and *Daphnia* mortality (P=0.0414).

Thus, in 2002, the 10 m buffer appeared to be sufficient in reducing pesticide concentrations to below acute lethality values. The buffer was also generally sufficient in reducing un-ionized ammonia concentrations, with the exception of one sample from one field at 10 m, where the un-ionized ammonia concentration exceeded the published 48-hour LC_{50} for *Daphnia magna*. In terms of toxicity, however, six of the samples collected at 10 m and one at 30 m were acutely toxic to *Daphnia* (from Fields 1, 2, 3, 5, and 6-2002 at 10 m and Field 5-2002 at 30 m). Therefore, in 2002, the 10 m buffer did not appear to be adequate in reducing toxicity to acceptable levels.

3.5 Rainfall in 2001 and 2002

Figure 12 depicts the total rainfall for up to 24 hours prior to the time when the runoff was collected, including the rainfall amount during the most intense hour in that period for 2001. Figure 13 depicts the total rainfall, the maximum hourly rainfall amount during the test period, and where available, the amount of rainfall collected in rainfall gauges placed at 5 of the 7 fields sampled for 2002. In 2001, the sample locations were within close proximity to each other and near the Maple Plains automated hydrometric station, therefore, all rainfall amounts were based on the volumes collected at the Maple Plains station. In 2002, five fields were located closer to Maple Plains and two fields were located closer to Summerside. Therefore, in 2002, rainfall amounts were based on rainfall collected at both Maple Plains and Summerside hydrometric stations. The purpose of these graphs is to indicate the volume of precipitation that occurred during a rainfall event in comparison to the volume of precipitation that occurred during the most intense hour. Logically, runoff would be expected to be associated with large volumes of rainfall over short periods of time, where the ground may be unable to absorb the rainfall as fast as it is falling. However, the saturation level of the ground is also important in determining the amount of precipitation needed to produce runoff (Webb, personal communication, 2004).

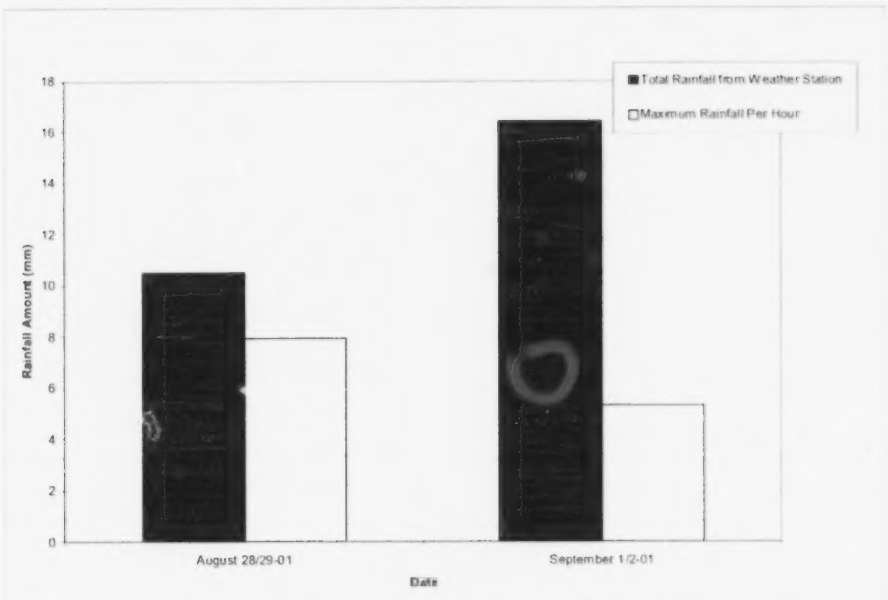

Figure 12: Total rainfall amount and maximum rainfall amount prior to each sampling event - 2001

In a comparison of number of samples collected and rainfall amounts in 2001, sufficient sample volumes were collected on September 1 for toxicity and chemistry at 0 and 10 m at 4 of the 5 fields, whereas on August 29, samples were only collected at 0 and 10 m at 2 of the 5 fields. Thus, despite the greater volume of intense rainfall (in one hour) prior to sample collection on August 29, more runoff was collected on September 1, where there was a greater total volume of rainfall that occurred with less intensity in the 24 hour period preceding sample collection.

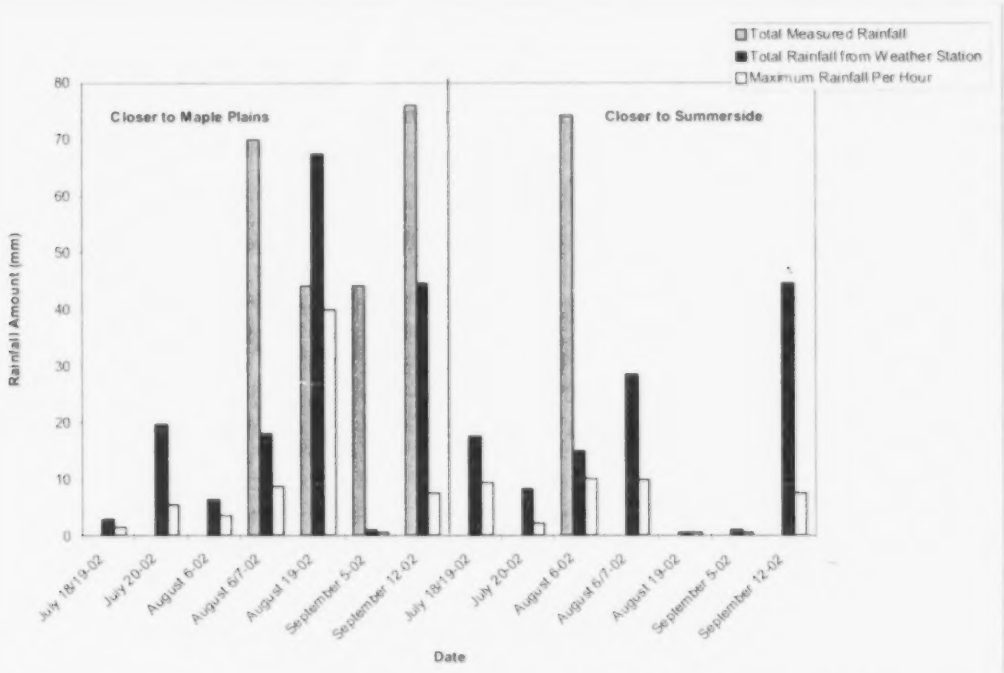

Figure 13: Total rainfall amount and maximum rainfall amount prior to each sampling event – 2002

In a comparison of the number of samples collected and rainfall amounts in 2002, the greatest number of runoff samples were collected on August 7 (samples at 0 m, 10 m, and at the 30 m site) for 6 of the 7 fields and partial collection at the seventh (0 m only). The second highest number of samples were collected on September 12, with collection at 0 m, 10 m and at 30 m at 5 of the 7 fields and partial collection at one field (0 m only). Full sample collection occurred on July 19 at 4 fields (0 m, 10 m and at the 30 m site), and partial collection on August 20 at four fields (collection at 0 m and 10 m at 2 of the 4 fields). Full or partial samples were collected from three fields on September 6, and two fields on July 20 and August 6.

Thus, in general, it appears that the greater the total volume of rainfall rather than the intensity may be partially responsible for runoff generation. The greatest number of runoff samples were collected on August 7 and September 12 where more than 70 mm of rainfall was reported, however, the most intense hour of rainfall during these two events yielded less than 10 mm, whereas only partial collection was obtained on August 20, following a measured rainfall of greater than 42 mm (and a reported measurement of greater than 60 mm from the nearby weather station), with the most intense hour yielding approximately 40 mm.

Due to a limited number of samples in 2001, no statistically significant correlations ($P \leq 0.05$) could be derived between rainfall amounts, and field slope, pesticide concentrations, un-ionized ammonia concentrations, and *Daphnia magna* toxicity. In 2002, no statistically significant correlations ($P \leq 0.05$) were identified between rainfall amounts and field or buffer slope, pesticide concentrations, un-ionized ammonia concentrations, or *Daphnia magna* toxicity. Thus, in 2002, rainfall amounts did not appear to directly influence pesticide concentrations, un-ionized ammonia concentrations, or *Daphnia* toxicity.

3.6 Field and Buffer Slopes – 2001 – 2002

Due to a limited number of samples in 2001, no statistically significant correlations ($P \leq 0.05$) could be derived comparing field slope percentages to pesticide concentrations, un-ionized ammonia concentrations or *Daphnia* toxicity. In 2002, no statistically significant correlations ($P \leq 0.05$) were identified between field and buffer slope percentages and pesticide concentrations, un-ionized ammonia concentrations and *Daphnia* toxicity. In addition, in combining the un-ionized ammonia concentrations and the *Daphnia* toxicity results from 2001 and 2002, no statistically significant correlations ($P \leq 0.05$) were identified between field and buffer slope percentages and un-ionized ammonia or *Daphnia* toxicity for 2001 and 2002 combined. Thus, field or buffer slope percentage does not appear to directly influence pesticide concentrations, un-ionized ammonia concentrations or *Daphnia* toxicity.

4.0 SUMMARY

In 2001, pesticide concentrations in the aqueous and particulate phases decreased with distance away from the field. Mean concentrations of azinphos-methyl and chlorothalonil in the aqueous portion of the sample exceeded acute toxicity values for *Daphnia magna* at 0 m but not at 10 m.

In 2002, with the exception of imidacloprid in the aqueous phase, mean pesticide concentrations in the aqueous and particulate phases decreased with distance away from the field. Mean imidacloprid concentrations decreased from 0 m to 10 m, and increased from 10 m to 30 m. Due to the solubility of imidacloprid in water and since samples were collected at 30 m at one field only, its water solubility and/or specific field dynamics may have contributed to this result. None of the mean pesticide concentrations in the aqueous portion of the sample exceeded acute toxicity values for *Daphnia magna* at 0, 10 or 30 m.

Since un-ionized ammonia and toxicity samples were not preserved prior to analysis, the results were combined. The mean concentration of un-ionized ammonia for both 2001 and 2002 decreased from 0

m to 10 m and from 10 m to 30 m. Concentrations exceeding the acute toxicity values for *Daphnia magna* were identified at 0 m but not at 10 m or 30 m, however, concentrations exceeding the acute toxicity values for salmonids were identified at both the 0 m and 10 m distance but not at 30 m from the field.

The combined 2001 and 2002 *Daphnia magna* results also showed decreasing toxicity with distance from the field. Elevated toxicity (>50% mortality or immobilization) was identified in 2001 in nine of 31 samples at 10 m (29%), and in one of five samples at 30 m (20% of the samples collected at 30 m). Although there was 100% *Daphnia* mortality in a few samples even up to distances of 30 m, mean immobilization rates exceeded 50% only at 0 m and mean mortality below 50% at all distances measured.

Pearson product moment correlations were evaluated by comparing the following parameters: field and buffer slope, rainfall amounts and intensity, pesticide chemistry data, un-ionized ammonia, and *Daphnia* toxicity. These correlations were evaluated for the chemistry data from 2001 and 2002 separately, but were evaluated for both 2001 and 2002 combined for the *Daphnia* toxicity and the un-ionized ammonia results. Due to a limited number of samples in 2001, no statistically significant correlations ($P<0.05$) could be made between pesticide concentrations, un-ionized ammonia concentrations, slope, total rainfall, maximum rainfall, and *Daphnia* toxicity.

In 2002, due to a sufficient number of samples, Pearson product moment correlations could be derived. Statistically significant correlations were identified between chlorothalonil concentrations and *Daphnia* immobility and *Daphnia* mortality ($P=0.0262$ and $P=0.0166$, respectively), and between un-ionized ammonia concentrations and *Daphnia* immobility and *Daphnia* mortality ($P=0.0178$ and $P=0.0298$, respectively). No statistically significant correlations were identified between *Daphnia* effects and other pesticides, slope, total rainfall and/or maximum rainfall.

For the combined dataset from 2001 and 2002 for un-ionized ammonia and *Daphnia* toxicity, a statistically significant correlation was identified between un-ionized ammonia and *Daphnia* mortality ($P=0.0414$).

Based on the results presented in this report, in 2001, the 10 m buffer zone was generally effective in reducing the pesticide concentrations of the runoff. In 2002, the 10 m buffer zone was effective at reducing the analysed pesticide concentrations, however, it was not effective at reducing the un-ionized ammonia to concentrations below acute toxicity values for *Daphnia magna*. The combined results of 2001 and 2002 toxicity testing indicated that there was generally a reduction in toxicity with distance from the edge of fields; however, that reduction was greatest from 0 to 10 m and there was very little difference from 10 to 30 m. In addition, chlorothalonil and un-ionized ammonia were strongly correlated with *Daphnia* toxicity indicating that the presence of elevated concentrations of either of these substances were associated with elevated toxicity, more than with the other parameters analysed.

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APPENDIX A

CHEMISTRY AND TOXICITY SUMMARY TABLES

Table A.1: Pesticide Concentrations 2001

Site	Sample Date	Location	Azinphos-Methyl ug/L	Endosulfan ug/L	Chlorothalonil ug/L	Phorate ug/L	Imidacloprid ug/L	Azinphos-Methyl (Filter) ug/L	Endosulfan (Filter) ug/L	Chlorothalonil (Filter) ug/L	Phorate (Filter) ug/L	Imidacloprid (Filter) ug/L
Field 1-2001	Aug 29-01	0 m	<0.3	<0.1	0.12	<0.05	<0.5	<0.1	<0.04	0.04	<0.02	<0.5
Field 1-2001	Aug 29-01	10 m	<0.3	<0.1	**0.66**	<0.05	<0.5	<0.1	0.03	0.03	<0.02	<0.5
Field 1-2001	Sept 2-01	0 m	0.3	<0.04	<0.02	<0.02	<0.5	<0.1	0.07	<0.02	<0.02	<0.5
Field 1-2001	Sept 2-01	10 m	0.4	<0.04	<0.02	<0.02	<0.5	<0.1	0.07	<0.02	<0.02	<0.5
Field 2-2001	Aug 29-01	0 m	***15.7***	<0.1	**0.94**	<0.05	11.9	6.4	0.06	<0.02	<0.02	0.8
Field 2-2001	Sept 2-01	0 m	***9.1***	<0.04	<0.02	<0.02	7.7	12.3	0.28	0.06	<0.02	1.2
Field 3-2001	Aug 29-01	0 m	<0.3	**2.24**	***155.5***	<0.05	<0.5	<0.1	3.71	27.48	<0.02	<0.5
Field 3-2001	Sept 2-01	0 m	0.6	**7.69**	***396.9***	<0.02	<0.5	<0.1	22.67	227.8	<0.02	<0.5
Field 3-2001	Sept 2-01	10 m	N/A	N/A	N/A	N/A	<4	N/A	N/A	N/A	N/A	<0.5
Field 4-2001	Aug 29-01	0 m	N/A	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	N/A	<0.5
Field 4-2001	Aug 29-01	10 m	N/A	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	N/A	<0.5
Field 4-2001	Sept 2-01	0 m	0.5	**4.42**	***350.6***	<0.02	<0.5	<0.1	28.67	1043	0.03	<0.5
Field 4-2001	Sept 2-01	10 m	N/A	N/A	N/A	N/A	<4	N/A	N/A	N/A	N/A	<0.5
Field 5-2001	Sept 2-01	0 m	0.5	**7.6**	***220.3***	<0.02	<0.5	<0.1	13.89	131.8	<0.02	<0.5
Field 5-2001	Sept 2-01	10 m	<0.3	<0.04	**25.71**	<0.02	<0.5	<0.1	0.29	0.32	<0.02	<0.5
CCME Criteria	-	-	N/A	0.02	0.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A
EC50			1.1	75-750	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LC50			N/A	N/A	129-202	37000	85000	N/A	N/A	N/A	N/A	N/A

Notes:
N/A - not available
Bolded value - exceeds CCME (2002) Freshwater Aquatic Life Guidelines
Bolded and Italicized value - exceeds literature-based LC or EC50

Table A.2 Pesticide Concentrations 2002

Site	Date	Location (m)	Azinphos-Methyl ug/L	Endosulfan ug/L	Chlorothalonil ug/L	Imidacloprid ug/L	Linuron ug/L	Metobromuron ug/L	Carbofuran ug/L	Azinphos-Methyl (Filter) ug/L	Endosulfan (Filter) ug/L	Chlorothalonil (Filter) ug/L	Carbofuran (Filter) ug/L	Linuron (Filter) ug/L	Metobromuron (Filter) ug/L	Imidacloprid (Filter) ug/L
Field 1-2002	Aug 7-02	0	<0.5	**6.1**	**99.7**	1.9	<0.2	<0.2	<0.2	<0.1	**0.4**	**0.8**	<0.1	<0.1	<0.1	<0.50
Field 1-2002	Aug 7-02	10	<0.5	<0.41	<0.23	NT	0.6	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	N/A
Field 1-2002	Sept 12-02	0	<0.5	**0.3**	<0.23	NT	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NT
Field 1-2002	Sept 12-02	10	<0.5	<0.23	NT	NT	NT	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	
Field 2-2002	Aug 7-02	0	<0.5	<0.41	***260.5***	NT	4.3	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NT
Field 2-2002	Aug 7-02	10	<0.5	<0.41	**61.9**	0.5	<0.2	<0.2	<0.2	<0.1	<0.2	0.1	<0.1	<0.1	<0.1	<0.50
Field 2-2002	Aug 20-02	0	<0.5	<0.41	<0.23	1.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 2-2002	Aug 20-02	10	<0.5	<0.41	**2.2**	0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 2-2002	Sept 12-02	0	<0.5	<0.41	**11**	6.9	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 2-2002	Sept 12-02	10	<0.5	<0.41	**0.8**	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	July 19-02	0	<0.5	<0.41	<0.23	0.8	<0.2	<0.2	<0.2	N/A	N/A	N/A	N/A	N/A	N/A	NT
Field 3-2002	July 19-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	N/A	N/A	N/A	N/A	N/A	N/A	NT
Field 3-2002	July 20-02	0	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	July 20-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Aug 6-02	0	<0.5	<0.41	<0.23	1.1	<0.2	<0.2	<0.2	<0.1	<0.2	**0.9**	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Aug 6-02	10	<0.5	<0.41	**0.4**	NT	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NT
Field 3-2002	Aug 7-02	0	<0.5	<0.41	***101***	0.8	<0.2	<0.2	0.5	<0.1	<0.2	**0.4**	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Aug 7-02	10	<0.5	<0.41	<0.23	<0.5	0.5	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Aug 20-02	0	<0.5	<0.41	<0.23	2.4	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Aug 20-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Sept 6-02	0	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Sept 6-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 3-2002	Sept 12-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 4-2002	Aug 7-02	0	<0.5	<0.41	***191.2***	0.6	**33**	<0.2	<0.2	<0.1	<0.2	**1.9**	<0.1	0.6	<0.1	<0.50
Field 4-2002	Aug 20-02	0	<0.5	<0.41	**74.2**	1.8	**73.3**	<0.2	<0.2	<0.1	<0.2	**18.5**	<0.1	6	<0.1	<0.50
Field 4-2002	Aug 20-02	10	<0.5	<0.41	<0.23	NT	3	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	N/A	<0.1	NT
Field 4-2002	Sept 6-02	0	<0.5	<0.41	<0.23	<0.5	**40.7**	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	0.5	<0.1	<0.50
Field 4-2002	Sept 6-02	10	<0.5	<0.41	<0.23	<0.5	3.8	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 4-2002	Sept 12-02	0	<0.5	<0.41	<0.23	<0.5	5	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 4-2002	Sept 12-02	10	<0.5	<0.41	<0.23	NT	2.3	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NT
Field 5-2002	July 19-02	0	<0.5	<0.41	<0.23	2.1	<0.2	<0.2	<0.2	N/A	N/A	N/A	N/A	N/A	N/A	NT
Field 5-2002	July 19-02	10	<0.5	<0.41	**0.5**	NT	<0.2	<0.2	<0.2	N/A	N/A	N/A	N/A	N/A	N/A	NT
Field 5-2002	July 19-02	30	<0.5	<0.41	<0.23	1.9	<0.2	<0.2	<0.2	N/A	N/A	N/A	N/A	N/A	N/A	NT
Field 5-2002	July 20-02	0	<0.5	<0.41	<0.23	0.6	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Aug 7-02	0	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Aug 7-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Aug 7-02	30	<0.5	<0.41	<0.23	0.6	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Aug 20-02	0	<0.5	<0.41	<0.23	0.7	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Aug 20-02	0	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Aug 20-02	10	<0.5	<0.41	<0.23	1.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Aug 20-02	30	<0.5	<0.41	<0.23	1.4	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Sept 6-02	0	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Sept 6-02	10	<0.5	<0.41	<0.23	0.6	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Sept 6-02	30	<0.5	<0.41	<0.23	0.8	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Sept 12-02	0	<0.5	<0.41	<0.23	2.1	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Sept 12-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 5-2002	Sept 12-02	30	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 6-2002	July 19-02	0	<0.5	<0.41	**93.3**	1	<0.2	<0.2	<0.2	N/A	N/A	N/A	N/A	N/A	N/A	NT
Field 6-2002	Aug 6-02	0	<0.5	<0.41	<0.23	1.2	<0.2	<0.2	<0.2	<0.1	<0.2	0.1	<0.1	<0.1	<0.1	<0.50
Field 6-2002	Aug 7-02	0	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 6-2002	Aug 7-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 7-2002	July 19-02	0	<0.5	<0.41	***184.4***	1	<0.2	<0.2	<0.2	N/A	N/A	N/A	N/A	N/A	N/A	NT
Field 7-2002	Aug 6-02	10	<0.5	<0.41	<0.23	NT	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NT
Field 7-2002	Aug 7-02	0	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 7-2002	Aug 7-02	10	<0.5	<0.41	<0.23	1	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
Field 7-2002	Sept 12-02	0	<0.5	<0.41	<0.23	NT	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NT
Field 7-2002	Sept 12-02	10	<0.5	<0.41	<0.23	<0.5	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.50
CCME Criteria			N/A	0.02	0.18	N/A	7	N/A	1.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A
EC50			1.1	75-750	N/A	N/A	750	44000	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LC50			N/A	N/A	129-202	85000	4000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
N/A - not available, NT - not tested
Bolded value - exceeds CCME (2002) Freshwater Aquatic Life Guidelines

Table A.3: Total Ammonia Concentrations 2001

Site	Date	Distance	Total Ammonia (mg/L NH-3)	Un-ionized Ammonia at 20*C (mg/L)
Field 1-2001	Aug 29-01	0 m	2.79	<0.01
Field 1-2001	Aug 29-01	10 m	2.45	<0.01
Field 1-2001	Sept 2-01	0 m	3.68	<0.01
Field 1-2001	Sept 2-01	10 m	1.8	<0.01
Field 2-2001	Aug 29-01	0 m	4.37	<0.01
Field 2-2001	Sept 2-01	0 m	1.71	<0.01
Field 3-2001	Aug 29-01	10 m	18.1	**0.16**
Field 3-2001	Sept 2-01	0 m	1.37	<0.01
Field 3-2001	Sept 2-01	10 m	0.55	<0.01
Field 4-2001	Aug 29-01	0 m	147	***8.75***
Field 4-2001	Aug 29-01	10 m	24.1	**0.3**
Field 4-2001	Sept 2-01	0 m	1.56	<0.01
Field 4-2001	Sept 2-01	10 m	1.38	<0.01
Field 5-2001	Aug 29-01	0 m	9.01	**0.05**
Field 5-2001	Aug 29-01	10 m	17.9	**0.05**
Field 5-2001	Sept 2-01	0 m	1.04	<0.01
Field 5-2001	Sept 2-01	10 m	0.21	<0.01

Notes:
Bolded value - unionized ammonia exceeds CCME (1999) (0.019 mg/L)
CCME (1999) - Canadian Council of Ministers of the Environment Freshwater Aquatic Life Guideline (1999)
Bolded and Italicized value - exceeds LC50 (2.94 mg/L) & CCME guidelines

Table A.4: Total Ammonia Concentrations 2002

Site	Sample Date	Distance	Total Ammonia (mg/L NH-3)	Un-ionized Ammonia at 20°C (mg/L)
Field 1-2002	Aug 7-02	0 m	0.1	< 0.01
Field 1-2002	Aug 7-02	10 m	N/A	N/A
Field 1-2002	Sept 12-02	0 m	18.8	**0.65**
Field 1-2002	Sept 12-02	10 m	203	***13.4***
Field 2-2002	Aug 7-02	0 m	38.3	**0.13**
Field 2-2002	Aug 7-02	10 m	0.5	< 0.01
Field 2-2002	Aug 20-02	0 m	2.1	< 0.01
Field 2-2002	Aug 20-02	10 m	1.3	< 0.01
Field 2-2002	Sept 12-02	0 m	2.2	< 0.01
Field 2-2002	Sept 12-02	10 m	0.5	< 0.01
Field 3-2002	July 19-02	0 m	4.6	< 0.01
Field 3-2002	July 19-02	10 m	1.1	< 0.01
Field 3-2002	July 20-02	0 m	1.7	< 0.01
Field 3-2002	July 20-02	10 m	1.1	< 0.01
Field 3-2002	Aug 6-02	0 m	4.2	< 0.01
Field 3-2002	Aug 7-02	0 m	0.4	< 0.01
Field 3-2002	Aug 7-02	10 m	1.9	< 0.01
Field 3-2002	Aug 20-02	0 m	7.5	0.01
Field 3-2002	Aug 20-02	10 m	1.2	< 0.01
Field 3-2002	Sept 6-02	0 m	9.3	**0.04**
Field 3-2002	Sept 6-02	10 m	0.4	< 0.01
Field 3-2002	Sept 12-02	10 m	0.9	< 0.01
Field 4-2002	Aug 7-02	0 m	12.6	**0.03**
Field 4-2002	Aug 7-02	10 m	0.2	< 0.01
Field 4-2002	Aug 20-02	0 m	2	< 0.01
Field 4-2002	Sept 6-02	0 m	4.4	0.01
Field 4-2002	Sept 6-02	10 m	1.9	0.01
Field 4-2002	Sept 12-02	0 m	0.3	< 0.01
Field 4-2002	Sept 12-02	10 m	3.3	**0.05**
Field 5-2002	July 19-02	0 m	1.2	< 0.01
Field 5-2002	July 19-02	10 m	10.4	0.01
Field 5-2002	July 19-02	30 m	2.6	< 0.01
Field 5-2002	July 20-02	0 m	0.3	< 0.01
Field 5-2002	Aug 7-02	0 m	5.2	0.01
Field 5-2002	Aug 7-02	10 m	1	< 0.01
Field 5-2002	Aug 7-02	30 m	3.5	0.01
Field 5-2002	Aug 20-02	0 m (horizontal)	2.4	0.01
Field 5-2002	Aug 20-02	0 m (vertical)	6.1	**0.03**
Field 5-2002	Aug 20-02	10 m	1.4	0.01
Field 5-2002	Aug 20-02	30 m	3.8	0.01
Field 5-2002	Sept 6-02	0 m (horizontal)	2.6	< 0.01
Field 5-2002	Sept 6-02	0 m (vertical)	71.4	**5.93**
Field 5-2002	Sept 6-02	10 m	2.9	< 0.01
Field 5-2002	Sept 6-02	30 m	1.2	< 0.01
Field 5-2002	Sept 12-02	0 m (horizontal)	0.9	< 0.01
Field 5-2002	Sept 12-02	0 m (vertical)	5	**0.13**
Field 5-2002	Sept 12-02	10 m	0.8	< 0.01
Field 5-2002	Sept 12-02	30 m	0.8	< 0.01
Field 6-2002	July 19-02	0 m	1.6	< 0.01
Field 6-2002	Aug 6-02	0 m	0.3	< 0.01
Field 6-2002	Aug 7-02	0 m	1.1	< 0.01
Field 6-2002	Aug 7-02	10 m	1	< 0.01
Field 6-2002	Sept 12-02	0 m	651	***86.9***
Field 6-2002	Sept 12-02	10 m	436	***37.8***
Field 7-2002	July 19-02	0 m	5.9	< 0.01
Field 7-2002	Aug 7-02	0 m	0.8	< 0.01
Field 7-2002	Aug 7-02	10 m	0.7	< 0.01
Field 7-2002	Sept 12-02	0 m	273	**23.7**
Field 7-2002	Sept 12-02	10 m	22.2	**0.16**

Notes:
Bolded value - unionized ammonia exceeds CCME (1999) (0.019 mg/L)
CCME (1999) - Canadian Council of Ministers of the Environment Freshwater Aquatic Life Guideline (1999)
Bolded and Italicized value - exceeds LC50 (2.94 mg/L) & CCME guidelines

Table A.5: *Daphnia Magna* Test Results 2001

Site	Date	Distance	% Mortality (Filtered)	% Effected (Filtered)	% Mortality (Unfiltered)	%Effected (Unfiltered)
Field 1-2001	Aug 29-01	0 m	0	0	0	10
Field 1-2001	Aug 29-01	10 m	0	0	0	0
Field 1-2001	Sept 2-01	0 m	0	0	**60**	**60**
Field 1-2001	Sept 2-01	10 m	10	10	0	0
Field 2-2001	Aug 29-01	0 m	20	***100***	***100***	***100***
Field 2-2001	Sept 2-01	0 m	20	***100***	***100***	***100***
Field 3-2001	Aug 29-01	10 m	0	0	0	0
Field 3-2001	Sept 2-01	0 m	***100***	***100***	***100***	***100***
Field 3-2001	Sept 2-01	10 m	N/A	N/A	0	0
Field 4-2001	Aug 29-01	0 m	***100***	***100***	***100***	***100***
Field 4-2001	Aug 29-01	10 m	***40***	***40***	***80***	***80***
Field 4-2001	Sept 2-01	0 m	***100***	***100***	***100***	***100***
Field 4-2001	Sept 2-01	10 m	N/A	N/A	0	0
Field 5-2001	Aug 29-01	0 m	20	20	0	0
Field 5-2001	Aug 29-01	10 m	0	0	10	10
Field 5-2001	Sept 2-01	0 m	***100***	***100***	***100***	***100***
Field 5-2001	Sept 2-01	10 m	0	0	0	0

Notes:

% Effected includes Mortality + Immobility

Bolded value - samples considered toxic to *Daphnia magna*, both filtered and unfiltered

Bolded and italicized value - samples considered toxic to *Daphnia magna* in unfiltered sample

Table A.6: *Daphnia Magna* Test Results 2002

Site	Date	Distance	% Mortality	%Effected
Field 1-2002	Aug 7-02	0 m	***90***	***90***
Field 1-2002	Aug 7-02	10 m	0	0
Field 1-2002	Sept 12-02	0 m	0	0
Field 1-2002	Sept 12-02	10 m	***100***	***100***
Field 2-2002	Aug 7-02	0 m	***80***	***90***
Field 2-2002	Aug 7-02	10 m	***100***	***100***
Field 2-2002	Aug 20-02	0 m	***40***	***80***
Field 2-2002	Aug 20-02	10 m	0	0
Field 2-2002	Sept 12-02	0 m	0	0
Field 2-2002	Sept 12-02	10 m	0	0
Field 3-2002	July 19-02	0 m	***100***	***100***
Field 3-2002	July 19-02	10 m	***100***	***100***
Field 3-2002	July 20-02	0 m	0	0
Field 3-2002	July 20-02	10 m	***60***	***80***
Field 3-2002	Aug 6-02	0 m	0	0
Field 3-2002	Aug 7-02	0 m	***90***	***100***
Field 3-2002	Aug 7-02	10 m	0	0
Field 3-2002	Aug 20-02	0 m	0	0
Field 3-2002	Aug 20-02	10 m	***40***	***40***
Field 3-2002	Sept 6-02	0 m	0	0
Field 3-2002	Sept 6-02	10 m	0	0
Field 3-2002	Sept 12-02	10 m	0	10
Field 4-2002	Aug 7-02	0 m	0	0
Field 4-2002	Aug 7-02	10 m	***100***	***100***
Field 4-2002	Aug 20-02	0 m	***70***	***70***
Field 4-2002	Sept 6-02	0 m	10	***90***
Field 4-2002	Sept 6-02	10 m	0	0
Field 4-2002	Sept 12-02	0 m	***90***	***100***
Field 4-2002	Sept 12-02	10 m	0	0
Field 5-2002	July 19-02	0 m	***100***	***100***
Field 5-2002	July 19-02	10 m	***100***	***100***
Field 5-2002	July 19-02	30 m	***100***	***100***
Field 5-2002	July 20-02	0 m	0	0
Field 5-2002	Aug 7-02	0 m	10	10
Field 5-2002	Aug 7-02	10 m	0	0
Field 5-2002	Aug 7-02	30 m	10	10
Field 5-2002	Aug 20-02	0 m	0	0
Field 5-2002	Aug 20-02	10 m	0	0
Field 5-2002	Aug 20-02	30 m	***40***	***40***
Field 5-2002	Aug 20-02	0 m	0	0
Field 5-2002	Sept 6-02	0 m (h)	0	0
Field 5-2002	Sept 6-02	0 m (v)	***100***	***100***
Field 5-2002	Sept 6-02	10 m	0	0
Field 5-2002	Sept 6-02	30 m	0	0
Field 5-2002	Sept 12-02	0 m (h)	0	0
Field 5-2002	Sept 12-02	0 m (v)	0	0
Field 5-2002	Sept 12-02	10 m	0	0
Field 5-2002	Sept 12-02	30 m	0	0
Field 6-2002	July 19-02	0 m	***100***	***100***
Field 6-2002	Aug 6-02	0 m	20	20
Field 6-2002	Aug 7-02	0 m	***100***	***100***
Field 6-2002	Aug 7-02	10 m	0	0
Field 6-2002	Sept 12-02	0 m	***100***	***100***
Field 6-2002	Sept 12-02	10 m	***100***	***100***
Field 7-2002	July 19-02	0 m	***100***	***100***
Field 7-2002	Aug 7-02	0 m	***100***	***100***
Field 7-2002	Aug 7-02	10 m	10	30
Field 7-2002	Sept 12-02	10 m	0	0
Field 7-2002	Sept 12-02	0 m	***100***	***100***

Notes:
% Effected includes Mortality + Immobility
Bolded and Italicized value - samples considered toxic to *Daphnia magna*

APPENDIX B

SAMPLE COLLECTION DATES, LOCATIONS, ANALYSES, AND TOXICITY - 2002

Table B.1: Sample Collection Dates, Locations and Analyses – 2002

Date	Fields	Number of Samples Collected	Number Analysed for Base/Neutral Pesticides	Number Analysed for Imidacloprid
July 19	Fields 3, 5, 6, 7-2002	7 (4 at 0 m; 2 at 10 m; 1 at 30 m)	7	6 (1 at 10 m not analysed)
July 20	Fields 3 and 5-2002	3 (2 at 0 m; 1 at 10 m)	3	3
August 6	Fields 3, 6 and 7-2002	4 (2 at 0 m; 2 at 10 m)	4	2 (both 10 m samples)
August 7	Fields 1, 2, 3, 4, 5, 6, and 7-2002	14 (7 at 0 m; 7 at 10 m; 1 at 30 m)	14	12 (1 at 0 m and 1 at 10 m not analysed)
August 20	Fields 2, 3, 4, and 5-2002	10 (5 at 0 m; 4 at 10 m; 1 at 30 m)	10	11 (1 at 10 m not analysed)
September 6	Fields 1, 2, 4, and 5-2002	7 (3 at 0 m; 3 at 10 m; 1 at 30 m)	7	7
September 12	Fields 1, 2, 3, 4, 5, 6, and 7-2002	12 (5 at 0 m; 6 at 10 m; 1 at 30 m)	12	8 (2 at 0 m and 2 at 10 m not analysed

Table B.2: Sample Collection Dates, Locations and Toxicity – 2002

Date	Fields	Number of Samples Collected	Number and Location of Samples Toxic to *Daphnia magna*
July 19	Fields 3, 5, 6, 7-2002	7 (4 at 0 m; 2 at 10 m; 1 at 30 m)	7 (4 at 0 m; 2 at 10 m; 1 at 30 m)
July 20	Fields 3 and 5-2002	3 (2 at 0 m; 1 at 10 m)	1 at 10 m
August 6	Fields 3 and 6-2002	2 at 0 m	0
August 7	Fields 1, 2, 3, 4, 5, 6, and 7-2002	15 (7 at 0 m; 7 at 10 m; 1 at 30 m)	7 (5 at 0 m; 2 at 10 m)
August 20	Fields 1, 2, 3, 4, and 5-2002	9 (5 at 0 m; 3 at 10 m; 1 at 30 m)	2 at 0 m (1 only for immobilization)
September 6	Fields 1, 2, 4, and 5-2002	8 (4 at 0 m; 3 at 10 m; 1 at 30 m)	2 at 0 m (1 only for immobilization)
September 12	Fields 1, 2, 3, 4, 5, 6, and 7-2002	15 (7 at 0 m; 7 at 10 m; 1 at 30 m)	5 (3 at 0 m; 2 at 10 m)

APPENDIX C

ECOTOXICOLOGICAL PROPERTIES OF PESTICIDES USED ON THE STUDY SITES 2001 AND 2002

Table C.1: Chemical and Toxicological Properties of Pesticides Used and Identified in 2001 and 2002

Substance	Toxicity (1) (Except where Indicated)	½ Life Values (1) (Except Where Indicated)	Water Solubility (2) (Except Where Indicated)	Environmental Quality Criteria (CCME) (ug/L)
Azinphos-methyl	***Daphnia* 48h LC_{50} = 1.1 ug/L** Fathead minnow 96h LC_{50} = 93 ug/L Rainbow trout 96h LC_{50} = 4.3 ug/L (5) Brown trout 96h LC_{50} = 4.0 ug/L	Soil - 5 days Water - 2 days	28 mg/L at 20°C	N/C
Azoxystrobin	***Daphnia* 48h EC_{50} = 259 ug/L (6)** Rainbow trout 96h LC_{50} = 470 ug/L Bluegill sunfish LC_{50} = 1100 ug/L (2)	Soil - moderately persistent in the absence of light (2) Water - Hydrolysis half-lives were estimated to be 11 and 110 years at pH values of 7 and 8 (2)	6 mg/L at 20°C	N/C
α-Endosulfan	*Daphnia* 48h LC_{50} = 75-750 ug/L **Fathead minnow 96h LC_{50} = 1.4 ug/L** **Rainbow trout 96h LC_{50} = 1.4 ug/L**	Soil - disappears rapidly Water - 35-37 days Phytodegradation - 3-7 days	0.53 mg/l at 25°C	0.02
β-Endosulfan	*Daphnia* 48h LC_{50} = 75-750 ug/L **Fathead minnow 96h LC_{50} = 1.4 ug/L** **Rainbow trout 96h LC_{50} = 1.4 ug/L**	Soil - 75% remaining after 2 yrs Water - 35-37 days Phytodegradation - 3-7 days	0.28 mg/l at 25°C	0.02
Carbofuran	***Daphnia* 48h LC_{50} = 38.6 ug/L** Fathead minnow 96h LC_{50} = 872 ug/L Rainbow trout 96h LC_{50} = 380 ug/L	Soil - 30-120 days Water - 6 hours Phytodegradation - 4 days	320 mg/L at 20°C	1.8
Chlorothalonil	**Daphnia 48 h LC_{50} = 129-202 ug/L (7)** Daphnia 48 h EC_{50} = 97-172 ug/L Rainbow trout 96h LC_{50} = 76 ug/L	Soil - 1-3 months Water - 0.18-8.8 days	0.6 mg/L at 20°C (4)	0.18
Cypermethrin	***Daphnia* 48h LC_{50} = 0.15 ug/L** Rainbow trout 96h LC_{50} = 0.69 ug/L	Soil - 4 days - 8 weeks Water - >50 days	0.004 mg/L at 20°C	N/C
Dimethoate	***Daphnia* 48h LC_{50} = 2500 ug/L** Rainbow trout 96h LC_{50} = 6200 ug/L	Soil - 2 to 4 days Water - 118 days (pH 7)	25 g/L water at 21°C	6.2
Diquat ion	***Daphnia* 48h LC_{50} = 2.2 ug/L (diquat dibromide) (6)** Brown trout 96h LC_{50} = 200,000 ug/L Rainbow trout 96h LC_{50} = 21,000 ug/L	Soil - highly persistent Water - 2-4 weeks	700 g/L at 20°C	N/C
Fluazifop-P-butyl	Daphnia 48h EC_{50} = >1.0 ug/L (6) Rainbow trout 96h LC_{50} = 1370 ug/L Bluegill sunfish 96h LC_{50} = 530 ug/L	Soil - 3 weeks Water - 2.2 years and 79 days (pH 7 and pH 8) (4)	1 mg/l at pH 6.5	N/C
Imidacloprid	***Daphnia* 48h LC_{50} = 85,000 ug/L** Rainbow trout 96h LC_{50} = 211,000 ug/L	Soil - 2 years Water - 1.4 days	69 mg/l at 20°C	N/C
Linuron	***Daphnia* 48 h LC_{50} = 750 ug/L** Rainbow trout 96h LC_{50} = 3150 ug/L	Soil - 30-150 days Water - sorbs to sediment	75 mg/l at 25°C	7
Mancozeb	***Daphnia* 48 h LC_{50} - 1300 ug/L (5)**	Soil - 6-15 days	6.2 ppm, pH 7.5, at	N/C

Table C.1: Chemical and Toxicological Properties of Pesticides Used and Identified in 2001 and 2002

Substance	Toxicity (1) (Except where Indicated)	½ Life Values (1) (Except Where Indicated)	Water Solubility (2) (Except Where Indicated)	Environmental Quality Criteria (CCME) (ug/L)
	Rainbow trout 48h LC_{50} = 2200 ug/L	Water - 1-2 days	25°C	
Metalaxyl-M	***Daphnia* 48h LC_{50} = 12,500-28,000 ug/L** Rainbow trout 96h LC_{50} = >100,000 ug/L	Soil - 7 - 170 days Water ->4 weeks	N/A	N/C
Methamidophos	***Daphnia* 48h EC_{50} = 270 ug/L** Rainbow trout 96h LC_{50} = 25,000-51,000 ug/L	Soil - few days Water - 91 years - model river (2)	>2 kg/L at 20°C	N/C
Metribuzin	***Daphnia* 48h LC_{50} = 4500-35,000 ug/L** Rainbow trout 96h LC_{50} = 64,000 ug/L	Soil - 17-60 days Water - 4.3 hours in surface water (2)	Slightly soluble in water	1.0
Paraquat ion	***Daphnia* pulex 48h LC_{50} = 1200-4000 ug/L** Brown trout 96h LC_{50} = 2500-13,000 ug/L Rainbow trout 96h LC_{50} = 32,000 ug/L	Soil - >1000 days Water - 8-12 days (removed from water)	Soluble in water	N/C
Phorate	Rainbow trout 96h LC_{50} = 13 ug/L **Bluegill sunfish 96h LC_{50} = 2 ug/L**	Soil - 5-68 days (biodegradation) (2) Water - 14 - 100 days (model river) (2)	50 mg/l at 25°C	N/C
Rimsulfuron	***Daphnia* 48h LC_{50} = >360,000 ug/L** Rainbow trout 96h LC_{50} = >390,000 ug/L	Soil - 1.7-4.3 days (3) Water -	<10 mg/L at 25°C	N/C
Thiophanate-methyl	*Daphnia* 48h LC_{50} = 20,200 ug/L **Rainbow trout 48h LC_{50} = 7800 ug/L**	Soil - 3-4 weeks Water - degrades in aqueous solution (25 deg C; 48 hr) by 60% to methyl benzimidazole-2-yl carbamate (MBC) (2)	26.6 mg/L at 20°C	N/C

Notes:

1) Environment Canada (1999)
2) TOXNET (2003)
3) Tomlin, C. (1984)
4) Budavari, S. (1996)
5) ECOTOX (2003)
6) Tomlin, C. (2000)
7) Ernst, et. Al. (1991)

N/C = no criteria

Highlighted study indicates test species with the greatest sensitivity to pesticide active ingredient – as indicated above, with the exception of α-Endosulfan, β-Endosulfan, Thiophanate-methyl (where the LC_{50} for trout was lower than the EC_{50} for *Daphnia*), phorate (for which no *Daphnia* EC_{50} was identified), and potentially fluazifop-P-Butyl (where the *Daphnia* EC_{50} exceeded the highest test concentration), all *Daphnia* EC_{50}s were lower than the LC_{50} for trout or other identified fish species.

APPENDIX D

POTENTIAL RATIONALE FOR ELEVATED DAPHNIA TOXICITY 2001-2002

Table D.1: Potential Rationale for Elevated Daphnia Toxicity - 2001

Site	Sample Date	Location	Un-ionized Ammonia at 20°C (mg/L)	Azinphos-Methyl ug/L	Endosulfan ug/L	Chlorothalonil ug/L	Imidacloprid ug/L	% Mortality (filtered)	% Effected (filtered)	% Mortality (unfiltered)	%Effected (unfiltered)	Potential Rationale for Elevated Toxicity
Field 1-2001	Sept 2-01	0 m	<0.01	0.3	<0.04	<0.02	<0.5	0	0	60	60	Parameters sorbed to particulates
Field 2-2001	Aug 29-01	0 m	<0.01	[redacted]	<0.1	0.94	11.9	20	100	100	100	Azinphos methyl
Field 2-2001	Sept 2-01	0 m	<0.01	[redacted]	<0.04	<0.02	7.7	20	100	100	100	Azinphos methyl
Field 3-2001	Sept 2-01	0 m	<0.01	0.6	7.69	[redacted]	<0.5	100	100	100	100	Chlorothalonil
Field 4-2001	Aug 29-01	0 m	[redacted]	NT	NT	NT	NT	100	100	100	100	Un-ionized ammonia
Field 4-2001	Aug 29-01	10 m	0.3	NT	NT	NT	NT	40	40	80	80	Parameters sorbed to particulates
Field 4-2001	Sept 2-01	0 m	<0.01	0.5	4.42	[redacted]	<0.5	100	100	100	100	Chlorothalonil
Field 5-2001	Sept 2-01	0 m	<0.01	0.5	7.6	[redacted]	<0.5	100	100	100	100	Chlorothalonil
CCME			0.019	N/A	0.02	0.18	N/A					
EC50			N/A	1.1	75	97-172	N/A					
LC50			2.94	N/A	N/A	129-202	85000					

Notes:
NT - Not tested
N/A - Not available
Yellow - Exceeds CCME freshwater aquatic life guidelines
Highlighted - Exceeds Daphnia magna 48-hour EC/LC50

Table D.1: Potential Rationale for Elevated Daphnia Toxicity - 2001

Site	Sample Date	Location	Un-ionized Ammonia at 20°C (mg/L)	Azinphos-Methyl ug/L	Endosulfan ug/L	Chlorothalonil ug/L	Imidacloprid ug/L	% Mortality (filtered)	% Effected (filtered)	% Mortality (unfiltered)	%Effected (unfiltered)	Potential Rationale for Elevated Toxicity
Field 1-2001	Sept 2-01	0 m	<0.01	0.3	<0.04	<0.02	<0.5	0	0	60	60	Parameters sorbed to particulates
Field 2-2001	Aug 29-01	0 m	<0.01	16.7	<0.1	0.94	11.9	20	100	100	100	Azinphos methyl
Field 2-2001	Sept 2-01	0 m	<0.01	9.1	<0.04	<0.02	7.7	20	100	100	100	Azinphos methyl
Field 3-2001	Sept 2-01	0 m	<0.01	0.6	7.69	1000.0	<0.5	100	100	100	100	Chlorothalonil
Field 4-2001	Aug 29-01	0 m	1.7	NT	NT	NT	NT	100	100	100	100	Un-ionized ammonia
Field 4-2001	Aug 29-01	10 m	0.3	NT	NT	NT	NT	40	40	80	80	Parameters sorbed to particulates
Field 4-2001	Sept 2-01	0 m	<0.01	0.5	4.42	350.6	<0.5	100	100	100	100	Chlorothalonil
Field 5-2001	Sept 2-01	0 m	<0.01	0.5	7.6	220.3	<0.5	100	100	100	100	Chlorothalonil
CCME			0.019	N/A	0.02	0.18	N/A					
EC50			N/A	1.1	75	97-172	N/A					
LC50			2.94	N/A	N/A	129-202	85000					

Notes:
NT - Not tested
N/A - Not available
Yellow - Exceeds CCME freshwater aquatic life guidelines
Highlighted - Exceeds Daphnia magna 48-hour EC/LC50

Table D.2: Rationale for Elevated Daphnia Toxicity - 2002

Site	Sample Date	Location	D.O. (mg/L)	Un-ionized Ammonia (mg/L)	Endosulfan (ug/L)	Chlorothalonil (ug/L)	Imidacloroprid (ug/L)	Linuron (ug/L)	Carbofuran (ug/L)	% Mortality	% Effected	Reason for Elevated Toxicity
Field 1 2002	Aug 7 02	0 m	9	<0.01	0.1	2991	1.9	< 0.2	< 0.2	90	90	Chlorothalonil
Field 1 2002	Sept 12 02	0 m	0.4	19.4	0.3	<0.23	NT	<0.2	<0.2	100	100	Un-ionized ammonia
Field 2 2002	Aug 7 02	0 m	8.7	0.13	<0.18	2991	NT	4.3	< 0.2	60	90	Chlorothalonil
Field 2 2002	Aug 7 02	10 m	8.7	<0.01	<0.18	61.9	0.5	< 0.2	< 0.2	100	100	Potentially chlorothalonil
Field 2 2002	Aug 20 2002	0 m	7.5	<0.01	<0.18	<0.23	1.5	<0.2	< 0.2	40	80	Unknown
Field 3 2002	July 19 2002	0 m	8.6	<0.01	<0.18	< 0.23	0.8	< 0.2	< 0.2	100	100	Unknown
Field 3 2002	July 19 2002	10 m	8.1	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	100	100	Unknown
Field 3 2002	July 20 2002	10 m	8.1	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	60	80	Unknown
Field 4 2002	Aug 7 02	0 m	8.6	<0.01	<0.18	101	0.8	<0.2	0.5	90	100	Chlorothalonil
Field 4 2002	Aug 7 02	0 m	8.6	<0.01	<0.18	191	0.6	33	< 0.2	100	100	Chlorothalonil
Field 4 2002	Aug 20 02	0 m	8.7	<0.01	<0.18	74.2	1.6	73.3	< 0.2	70	70	Potentially chlorothalonil
Field 4 2002	Sept 0 02	0 m	8.7	0.01	<0.18	<0.23	<0.5	40.7	< 0.2	10	90	Sprayed methamidophos - LC50 = 0.27 mg/L (Aug 29)
Field 4 2002	Sept 12 02	0 m	9	<0.01	<0.18	<0.23	<0.5	5	< 0.2	90	100	Sprayed methamidophos - LC50 = 0.27 mg/L (Aug 29); small GC/MS peak in elemental sulfur and ethylenethiourea
Field 5 2002	July 19 2002	0 m	8.6	<0.01	<0.18	<0.23	2.1	<0.2	< 0.2	100	100	Unknown
Field 5 2002	July 19 2002	10 m	8.1	0.01	<0.18	0.5	NT	< 0.2	< 0.2	100	100	Unknown
Field 5 2002	July 19 2002	30 m	8.6	<0.01	<0.18	< 0.23	1.8	< 0.2	< 0.2	100	100	Unknown
Field 6 2002	Sept 0 02	0 m	7.7	5.09	<0.18	<0.23	<0.5	<0.2	< 0.2	100	100	Un-ionized ammonia
Field 6 2002	July 19 2002	0 m	9.1	<0.01	<0.18	93.3	1	< 0.2	< 0.2	100	100	Potentially chlorothalonil
Field 6 2002	Aug 7 02	0 m	7.8	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	100	100	Large GC/MS peak in elemental sulfur, a peak in ethylenethiourea, small peak for metribuzin, and small peak for metalaxyl
Field 6 2002	Sept 12 02	0 m	< 0.1	36.9	NT	NT	NT	NT	NT	100	100	Un-ionized ammonia
Field 6 2002	Sept 12 02	10 m	< 0.1	37.8	NT	NT	NT	NT	NT	100	100	Un-ionized ammonia
Field 7 2002	July 19 2002	0 m	9	<0.01	<0.18	1044	1	< 0.2	< 0.2	100	100	Chlorothalonil
Field 7 2002	Aug 7 02	0 m	8.3	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	100	100	Large GC/MS peak in elemental sulfur, a peak in ethylenethiourea, small peak for metribuzin, and small peak for metalaxyl
Field 7 2002	Sept 12 02	0 m	0.1	23.7	<0.18	<0.23	NT	<0.2	< 0.2	100	100	Un-ionized ammonia
CCME			N/A	0.019	0.02	0.18	N/A	120	1.8			
LC50			N/A	N/A	75	97 - 172	N/A	N/A	N/A			
LC50			2.2	1	N/A	129 - 202	85 000	750	15			

NT - not tested
Orange - exceeds CCME
Red - exceeds EC/LC50
Orange - doesn't exceed but is included as it may be the cause of the increased mortality/effect identified

Table D.2: Rationale for Elevated Daphnia Toxicity - 2002

Site	Sample Date	Location	D.O. (mg/L)	Un-ionized Ammonia (mg/L)	Endosulfan (ug/L)	Chlorothalonil (ug/L)	Imidacloroprid (ug/L)	Linuron (ug/L)	Carbofuran (ug/L)	% Mortality	% Effected	Reason for Elevated Toxicity
Field 1-2002	Aug 7-02	0 m	9	<0.01	6.1		1.9	< 0.2	< 0.2	90	90	Chlorothalonil
Field 1-2002	Sept 12-02	10 m	0.4		0.3	<0.23	NT	<0.2	<0.2	100	100	Un-ionized ammonia
Field 2-2002	Aug 7-02	0 m	5.7	0.13	<0.18		NT	4.3	< 0.2	80	90	Chlorothalonil
Field 2-2002	Aug 7-02	10 m	8.7	<0.01	<0.18	61.9	0.5	< 0.2	< 0.2	100	100	Potentially chlorothalonil
Field 2-2002	Aug 20-02	0 m	7.5	<0.01	<0.18	<0.23	1.5	<0.2	< 0.2	40	80	Unknown
Field 3-2002	July 19-2002	0 m	8.6	<0.01	<0.18	< 0.23	0.8	< 0.2	< 0.2	100	100	Unknown
Field 3-2002	July 19-2002	10 m	8.1	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	100	100	Unknown
Field 3-2002	July 20-2002	10 m	6.3	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	60	80	Unknown
Field 3-2002	Aug 7-02	0 m	8.6	<0.01	<0.18		0.8	<0.2	0.5	90	100	Chlorothalonil
Field 4-2002	Aug 7-02	0 m	8.6	<0.01	<0.18		0.6	33	< 0.2	100	100	Chlorothalonil
Field 4-2002	Aug 20-02	0 m	8.7	<0.01	<0.18	74.2	1.8	73.3	< 0.2	70	70	Potentially chlorothalonil
Field 4-2002	Sept 6-02	0 m	8.7	0.01	<0.18	<0.23	<0.5	40.7	< 0.2	10	90	Sprayed methamidophos - LC50 = 0.27 mg/L (Aug 29)
Field 4-2002	Sept 12-02	0 m	9	<0.01	<0.18	<0.23	<0.5	5	< 0.2	90	100	Sprayed methamidophos - LC50 = 0.27 mg/L (Aug 29); small GC/MS peak in elemental sulfur and ethylenethiourea
Field 5-2002	July 19-2002	0 m	8.6	<0.01	<0.18	< 0.23	2.1	< 0.2	< 0.2	100	100	Unknown
Field 5-2002	July 19-2002	10 m	6.1	0.01	<0.18	0.5	NT	< 0.2	< 0.2	100	100	Unknown
Field 5-2002	July 19-2002	30 m	8.8	<0.01	<0.18	< 0.23	1.9	< 0.2	< 0.2	100	100	Unknown
Field 5-2002	Sept 6-02	0 m (v)	3.7		<0.18	<0.23	<0.5	<0.2	< 0.2	100	100	Un-ionized ammonia
Field 6-2002	July 19-2002	0 m	9.1	<0.01	<0.18	93.3	1	< 0.2	< 0.2	100	100	Potentially chlorothalonil
Field 6-2002	Aug 7-02	0 m	7.8	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	100	100	Large GC/MS peak in elemental sulfur, a peak in ethylenethiourea, small peak for metribuzin, and small peak fo metalaxyl
Field 6-2002	Sept 12-02	0 m	< 0.1		NT	NT	NT	NT	NT	100	100	Un-ionized ammonia
Field 6-2002	Sept 12-02	10 m	< 0.1		NT	NT	NT	NT	NT	100	100	Un-ionized ammonia
Field 7-2002	July 19-2002	0 m	9	<0.01	<0.18		1	< 0.2	< 0.2	100	100	Chlorothalonil
Field 7-2002	Aug 7-02	0 m	8.3	<0.01	<0.18	< 0.23	< 0.5	< 0.2	< 0.2	100	100	Large GC/MS peak in elemental sulfur, a peak in ethylenethiourea, small peak for metribuzin, and small peak fo metalaxyl
Field 7-2002	Sept 12-02	0 m	0.1		<0.18	<0.23	NT	<0.2	< 0.2	100	100	Un-ionized ammonia
CCME			N/A	0.019	0.02	0.18	N/A	120	1.8			
EC50			N/A	N/A	75	97 – 172	N/A	N/A	N/A			
LC50			2.2	1	N/A	129 – 202	85,000	750	15			

NT - not tested
Yellow - exceeds CCME
Red - exceeds EC/LC50
Orange - doesn't exceed but is elevated and may be the cause of the increased mortality/effect identified